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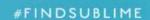


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THE LEGEND AMONG ICONS.



Portugieser Annual Calendar.

Ref. 5035: It took Portugal's ocean-going heroes centuries to become legends; IWC's Portugieser took just 75 years. For it is that long since the appearance of the first IWC Portugieser with a pocket watch movement marked the beginning of a new legendary era. And that revolutionary step forward is still mirrored today in the IWC-manufactured 52850 calibre. The fact that innovative new technology no longer needs

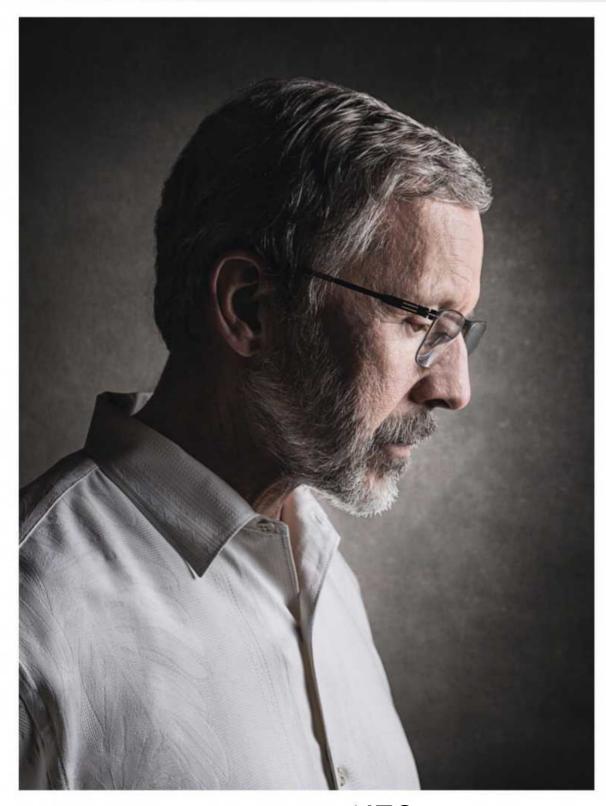
an eternity to achieve legendary status can be seen in the annual calendar, where the month, date and day can be read off at a glance. IWC. ENGINEERED FOR MEN.

Mechanical movement, Pellaton automatic winding, IWC-manufactured 52850 calibre, 7-day power reserve, Power reserve display, Annual calendar with displays for the month, date and day, Sapphire glass, See-through sapphire-glass back, Waterresistant 3 bar, Diameter 44.2 mm



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COVER FEATURE

How Pixar embraces a crisis

The animation giant's new film was falling apart. John Lasseter's response offers lessons to every business



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START

Red mist descends

Kuwait Oasis is working to defend its cities from sandstorms – by planting 315,000 trees along the county's border

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START

Grounds for sustainability

Arthur Kay is turning your cafetiére sludge into a biofuel to power the sustainable cities of the future

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START

How to put oil back in the Earth

Singapore is digging deep to store its hydrocarbon stockpile – by creating a 1.5-million-m³ underground oil reservoir

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Rated and reviewed

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An industrial giant thinks small

GE Appliances used to spend years – and millions – developing new products. Today, its spin-off creates in a matter of months

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Finnish games developer Supercell created hit games *Clash of Clans* and *Hay Day* – and killed every project it's worked on since



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A battle over diversity is raging in the world of science fiction. And it's a fight for the soul of popular culture



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CONTRIBUTORS

GUY SHIELD

Shield drew our inaugural Illustrated Experiment in R&D. "I wanted to show the intricacies of something that's technical, but engaging," he says. "I watched videos of the experiments, and they looked surprisingly humane, so I tried to get that across, too."



Figurative painter and illustrator Rico White portrays Slack CEO Stewart Butterfield for Big Question: "I paint in oils and like to show my workings on the canvas - it gives a sense of progression and helps capture the essence of the person."



KATHRYN NAVE

A regular contributor to WIRED, Nave guest-edits Start this month. "It was great to see the section from the inside," she says. "Start is about new thinking and ideas that break with how things are usually done. It was a challenge, but an exciting one."



JOÃO MEDEIROS

WIRED's science editor gets early looks at all kind of progress in his field - but often we don't have space to feature it. So, we've introduced R&D, a section designed to "blow our readers' minds," he says. "Crucially, it has a comic for explaining complex experiments."



SUN LEE

Lee turns his camera on to our Gear of the Year product special this month: "I have a taste for the minimalist, but it's great to see a diverse range of objects," he says. "I loved the Meccano robot - repositioning its arms via an iPhone app was ridiculously fun."



MATTHEW SYED

The author of *Black Box Thinking* writes in Ideas Bank on our collective duty to ignore hurt pride and learn from our mistakes. "The threat to ego, to reputation, to vanity - it obliterates progress," he says. "Great institutions leverage failure to drive change."



This month's cover feature on John Lasseter and Pixar was written by assistant editor Oliver Franklin-Wallis, with the shoot directed by deputy picture editor Dalia Nassimi: "When the photographer finished, John grabbed a Sharpie and just drew Toy Story's Buzz and Woody on the table in front of him," says Franklin-Wallis. "You can see why he's so loved at Disney - his creativity is infectious."





OFF-PAGE

WANT MORE WIRED?

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MAGAZINE

THE APP TAKES OVER

"I'm leafing through @WiredUK's @Facebook feature (One app to run your life, 11.15) and I can't help feel that Facebook's intention is outright frightening. The company might present itself as neutral but its intentions suggest nothing less than spectral domination of a communication medium. I remember the captive portal era of AOL, and I feel that Facebook is positioning itself as just that, using user data as subsidies. Facebook is one of the most popular communication mediums, and it's frightening to consider the implications if it begins to exert control. It's already demonstrating these implications [with its real name policy], as is happening to @violetblue and @PennyRed." @scott ainslie, via a series of tweets

FEEDBACK

STYLING TIPS

"Isn't WIRED's decision to italicise app names bizarre? They are not epic poems or academic journals." @tomstandage



MAGAZINE

DELIVER THE GOODS

"I'm one of those 'lucky few' who pre-ordered the first batch of Sproutlings (Gadi Amit: Under the skin, 10.15). The company planned to ship the device in May. Then 'late summer'. It's October now, and I haven't had a word since February. The last blog post on its website is more then a year old. Are you sure the company is still in business?" Alexander Veshev. via Facebook



Want to air your views on WIRED? Get in touch: rants@wired.co.uk

WIRED.CO.UK

TAKE A HAIKU

MAVEN CARRIES VERSE AND A FORGOTTEN BOTTLE OF LEAKING WATER

[RE: Haiku-carrying robotic probe slips into Mars orbit, wired.co.uk]
Dhrupad Marwa, via Facebook

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THINK DIFFERENT

"I hate hearing stories about people trying to 'cure' autism (Steve Silberman: Why are we still treating autism like an epidemic? 10.15). Ridding the world of it could be a very dangerous thing. Many scientists display 'autistic-like' traits, as do many artists and people of intellect. Also, many people may go through life with some autistic traits and never know about it. You could have it and never know." Perri Wheeler, via Facebook

WIRED.CO.UK

PRETTY ANNOYING

"I'm a girl in the age group Pretty Curious is aimed at (EDF's Pretty Curious STEM campaign criticised for 'sexist' name, wired.co.uk). The only way to get girls involved is to target everyone's individual interests as people, and not by directly targeting women as a gender. Projects like Pretty Curious try to pinkify everything, and yet other projects take a very masculine approach – there is no middle ground! Why can't these major companies treat young, budding engineers as individuals, rather than trying to motivate them based on their gender?" Olivia Bryant, via wired.co.uk

BVLGARI



MAN
IN BLACK













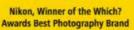
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We've banned the word "disruption" in the WIRED office. With due respect to Clayton Christensen, it's a 50p fine to the team's current charity of choice for using the business buzzword du jour - simply because everywhere we look, a corporate strategist is warning

a successful CEO about the teenager who's disrupting traditional revenue models, or a startup founder is brazenly threatening to disrupt any industry ranging from pet food to sex toys (usually by promising to be the "Uber of X").



So you may have to indulge us a little this month, when for our business-themed edition we may possibly have allowed the word to slip into one or two of our pages. That's because we wanted to take a close look at how some very different corporate cultures are building huge

growth by ignoring the traditional rules. And how - by leveraging the new tools of iterative product design, cross-industry collaboration and built-in digital virality - their executives have valuable lessons to teach the rest in an era of massive change.

We visited three businesses that all touch our lives in different ways. GE, one of the world's largest industrial companies that goes back to Edison, is working with startups to keep it thinking nimbly as it leverages its vast IP portfolio. Pixar knows how to sustain creative thinking even when projects appear to be failing - as anyone who read Ed Catmull's excellent Creativity, Inc. will already know. And Supercell, a company barely five years old, is making \$5 million even on its quieter days, largely from a single compelling game designed for the digital consumer. In a networked economy, crazy things can happen (such as a free smartphone game, launched last year by Kim Kardashian's team, that managed to earn \$43 million through in-game purchases in just five months). Who needs an MBA?

Sharon Calahan, director of photography on Pixar's The Good Dinosaur

We launch a new section this month:

R&D, our chance to showcase some of the extraordinary scientific research that we're seeing. We're in a world where sci-fi ideas are moving from the lab to the mainstream in ever-shorter cycles - so R&D is where you'll have early access to the significant research projects

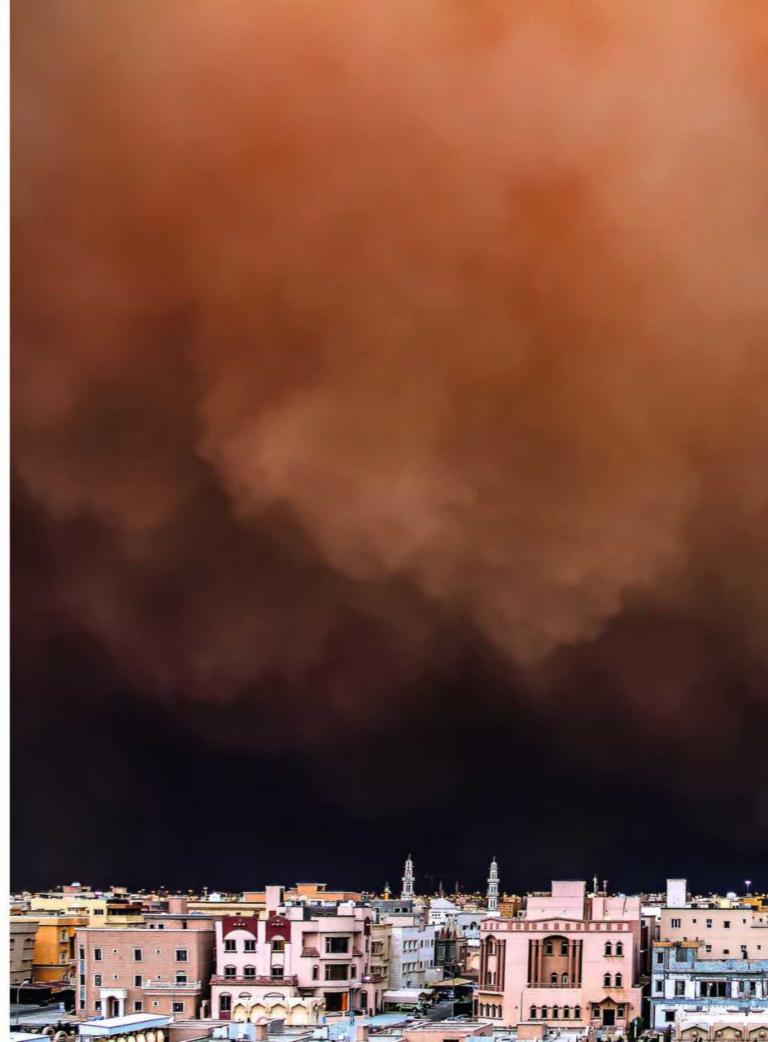
that are going to put bioelectronics, nano-replicators, or any other future concepts on the map. Of course, the section will be grounded in the people who excite us - neuroscientist David Eagleman, for instance, who combines brain studies with best-selling fiction. And, more importantly, it will have WIRED's first, regular, illustrated experiment. That's progress...

FROM THE FNITAR





David Rowan



PHOTOGRAPHY: RIZALDE CAYANAN

RED MIST Descends

This is Kuwait City as another sandstorm rolls in from Iraq. Hundreds of metres high, they travel across from the Arabian Desert at speeds of up to 100kph, costing the region's economies dearly. "They have increased remarkably," says Essa Ramadan, senior meteorologist at the Kuwait Meteorological Department. The reasons? "Dam-building in Turkey, climate change and the environmental destruction in the wake of the Gulf War."

But Kuwait is fighting back. Volunteer organisation Kuwait Oasis is working to plant 315,000 trees along the country's borders by 2019 to hold back the moving sands. A similar initiative in Mongolia's Kubuqi Desert reduced sandstorms from 80 a year to fewer than five. Both use Waterboxx plant incubators from **Dutch startup Groasis** Technologies. These collect water from the air at night via condensation and prevent its evaporation during the day, meaning each tree consumes 35 times less water than with standard drip irrigation.

One factor that isn't helping the cause, however, is war. "Conflicts are a big barrier," says Ramadan. "Ultimately we need the co-operation of Iraq, Syria and Saudi Arabia." KN kuwait-oasis.com



FOLLOW THE (NANO) CROWD

Sabine Hauert is fighting cancer by harnessing the science of swarms and self-organising particles

Sabine Hauert and some of her 1,000 Kilobots, which test nanoparticle interactions at a macro scale

O

abine Hauert wants to inject cancer patients with a trillion killer nanobots. The 32-year-old swarm engineer at the Bristol Robotics Laboratory is building smart nanoparticles that can work together as targeted cancer killers.

"Research has shown that smart nanoparticles can communicate through the environment, like ants laying trails for the rest of the swarm to follow," she explains. One study found that communicating nanoparticles can deliver a 40 times higher dose of anti-cancer drugs to a tumour than those that don't interact.

Hauert's nanoparticles have no embedded electronics or software to guide them – their size, shape, coating and composition have been designed to create communication and swarm-like behaviour. "They can react to light, magnetic fields or chemicals," she says.

To help identify useful combinations, Hauert created a crowdsourcing platform called NanoDoc, allowing anyone to design a nanoparticle. More than 80.000 simulations have been run since its launch in September 2013. Last August, Hauert assembled a 1,000strong swarm of Kilobots - simple 33mm robots designed at Harvard University - to test these simulations on a macro scale. Its findings: her nanoparticles had a small bug. "They would actually just stick to the first cancer cell they met, rather than penetrating deep into the tumour," she says. The solution: "A two-step nanoparticle with a coating that slowly wears off, allowing the smart particle to go deeper into the tumour."

Ultimately, she believes that the lessons learned in designing her particles can be applied to collectives of much larger robots, whether for cleaning up an oil spill or finding victims of an earthquake. Power to the swarm. Mark Piesing sabinehauert.com



The Microsoft Cloud gives Special Olympics instant access to key performance and health data for every athlete, no matter where they are. Microsoft Azure and Office 365 help streamline the management of 94,000 events across 170 countries each year. So the focus can be on changing the lives of athletes, and that's the true victory.

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A BRIDGE FOR DISASTERS

when a Major Flood or Earthquake Strikes, People Need Help – Quickly. One challenge is getting to them. Roads can crack open; fields can wash away; bridges can collapse. Temporary structures have not always proved practical – they are too flimsy or take days to set up. But Ichiro Ario and his team at Hiroshima University hope to fill that void with the Mobilebridge, a collapsible overpass that can rapidly span gaps and support cars carrying emergency supplies. Though Ario's studies in materials science and origami informed the design, the real inspiration for the accordion-like mechanism came from watching his son play with a toy pistol: whenever he pulled the trigger, a section of the barrel would scissor out. The Mobilebridge is just three metres thick all folded up, but flick a switch and the steel and aluminium structure flattens out in spectacular fashion to more than 21 metres. "It's like a robot bridge or a bridge machine," Ario says. For a test earlier this year, workers towed the Mobilebridge by trailer to Japan's Hongo River, where installation took about an hour. That's fast – and in a real emergency, speed makes all the difference. Lydia Belanger







Traditional temporary bridges take several days to assemble. The Mobilebridge can be installed in an hour – and expands in just five minutes





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028 / START / PERILOUS PARTICLES

YOU THINK YOUR WORKPLACE IS TOXIC...

Any survey of the world's worst working environments would have to put Egypt's hazardous limestone quarries near the top

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HESE LIMESTONE QUARRIES IN MINYA, EGYPT,

may be one of the world's most dangerous work environments. Obvious hazards include the stonecutters and drivers speeding through clouds of dust, but the chief killer is the limestone itself. "In Egypt, we lack industrial hygiene," says Medhat Kalliny, assistant professor of family and community medicine at Meharry Medical College in Nashville, Tennessee, who has researched Egyptian mines. "Workers inhale a lot of dust. This contains high levels of silica so it can cause silicosis."

Silicosis infiltrates the lungs, triggering fibrosis in the damaged tissue. This excess of fibroblasts reduces the worker's breathing capacity. "You will have a cough, a shortness of breath, inability to do physical work," says Kalliny, adding that silicosis can cause heart damage,

known as pulmonary hypertension. And it is incurable. The only solution lies in preventative measures. "If you find a worker wearing a mask then it will just be a regular surgical mask. For this kind of dust exposure you need to be wearing more advanced equipment."

Things are slowly changing. Following the 2011 Egyptian Revolution, with the assistance of local organisation Wadi el Nil, the quarry workers formed a union, successfully turning a threatened daily wage reduction into a pay rise of five Egyptian lira. Wadi el Nil also helps the wives of quarrymen no longer able to work to set up micro-businesses to support their families. But what is really needed, Kalliny says, is government regulation of health and safety. "In the west there are permissible exposure limits," he explains. "We don't have such a thing in Egypt." Sophia Epstein



1. HIGH-RISK MACHINERY

A worker uses a rotor blade to cut blocks of limestone. Equipment is often homemade and employers are not responsible for staff safety.

2. UNDERAGE WORKERS

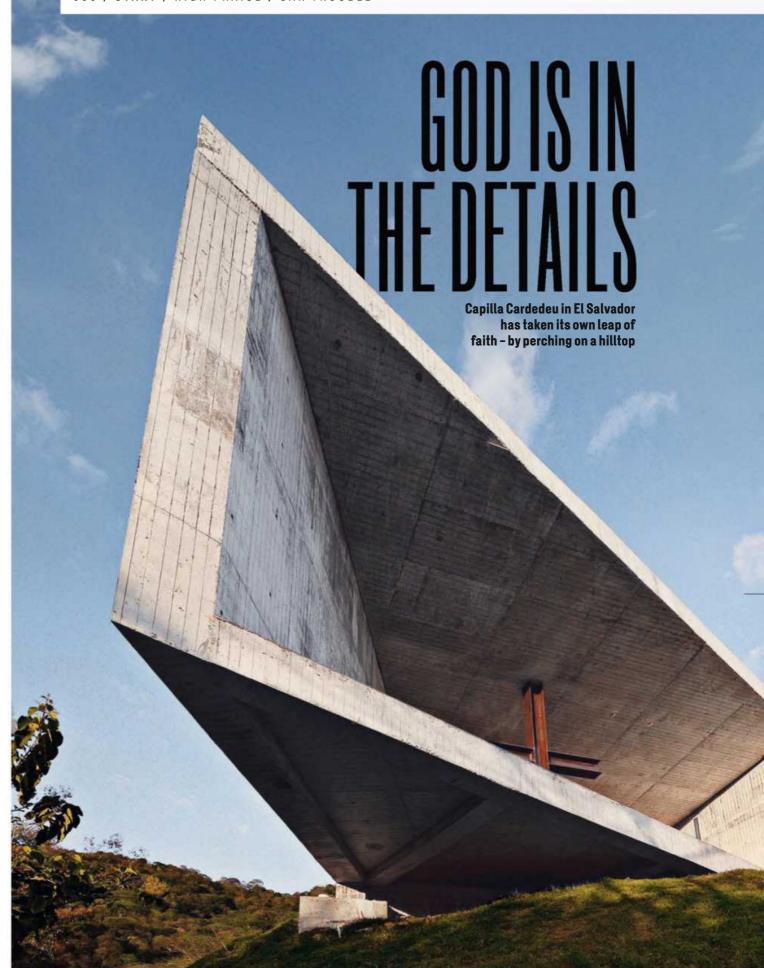
Children as young as ten work in the searing heat of the Egyptian quarries. The Nile Valley Foundation recently found that 23 per cent of the quarry workforce are underage.



Microsoft Azure scales to enable AccuWeather to respond to 10 billion requests for crucial weather data per day. This cloud rises to the challenge when the weather is at its worst.

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THIS CONCRETE AND STEEL

slab perched precariously on an El Salvador hillside is a chapel. Surrounded by mountains and overlooking the volcanic Coatepeque Lake, the 182m² Capilla Cardedeu was conceived as a frame for the landscape, so EMC Arquitectura, the Salvadoran firm behind the project, designed it as a wedge-shaped building that's open on two sides. "We wanted to highlight the lake, taking the attention away from other distracting elements," explains Eva Hinds, who designed the chapel and other surrounding buildings, which together form part of an event space. "The chapel is wider and higher on the open side facing the lake."

This configuration allows air to circulate constantly inside the building, making the tropical climate bearable for the congregations. It is aided by the internal structure of the walls, with two layers of concrete separated by a buffer of air to absorb excess heat. The projecting corner is kept stable by concrete frames and two steel I-beams. "The ground was sunken on one side, and at the same time that particular spot was the first thing one would see when approaching the area," says Hinds. "We designed the building so that from the road below you see what looks like a flying chapel."

Capilla Cardedeu is among the finalist projects at the World Architecture Festival in Singapore which takes place in November. It certainly has an edge. Gian Volpicelli emcarquitectura.com

One of two supporting I-beams is cut to form a cross shape that sits at the front of the chapel







oris Danev hacks

cars. But the 36vear-old computer scientist isn't a criminal - he's the CEO of Zurich startup 3DB Technologies, which wants to make cars more secure. "Currently, 95 per cent of major European car brands - Mercedes, Audi, BMW, Jaquar, Bentley, Renault, Toyota, Lexus use keyless entry, which means the car automatically unlocks when you're nearby," says Danev. "What we discovered in our research is that all these cars use the same technology and it can be hacked surprisingly easily."

While a PhD student at ETH Zurich, Danev,

Pictured: Boris Danev (in the car) and Srdjan Capkun supervised by his professor Srdian Capkun, hacked into several cars and was able to open and drive them all. "We asked a car owner in Zurich to leave his keyless remote where he usually leaves it - on his kitchen table," Daney says, "Using our device, which intercepted and amplified the signal, the keyless remote could answer back to the car from inside the home. The car opened up and my colleague drove off."

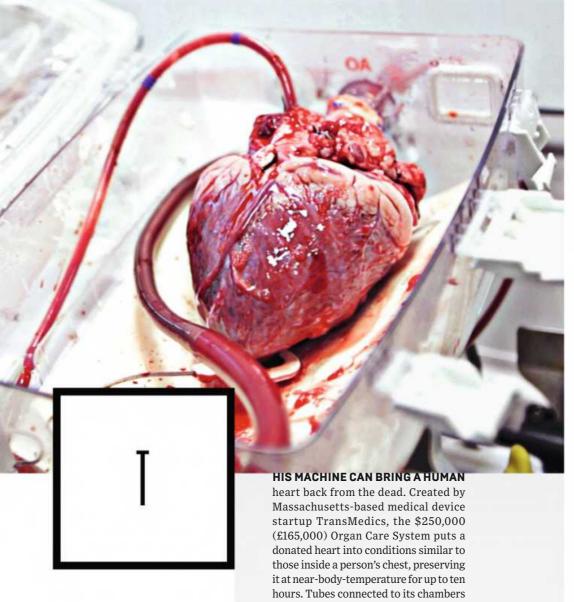
Spun out from ETH in June 2012, the startup has designed a smart chip for keyless remotes. "Our chip is a piece of silicon, roughly 5mm by 5mm, and can fit inside a key," says Danev. When you try your car door, it

sends a signal to the key chip and starts a stopwatch. The keyless remote sends a response to the car, so the car can calculate the distance between itself and the remote. "The manufacturer can set the threshold at two metres, three metres, whatever vou want. We make the distance measurement using speed of light, so the car will know precisely how far it is from the key."

Danev is now discussing the integration of the chip into keys made by a range of car manufacturers such as Audi and BMW; he hopes it will be on shelves by 2018. "We have our proof of technology –we know it works." MV 3db-technologies.com

THESE MEN HACKED YOUR CAR

But only to make it more secure, Boris Danev explains



cycle through a one-litre supply of the donor's blood and other nutrients, and a canister in the machine provides the oxygen. "Half of the time, once we begin perfusing the organ, it starts beating spontaneously," explains TransMedics vice president of global marketing Neal Beswick. "Otherwise, we use a small defibrillation pulse to give it a kick-start."

This system – already in use throughout Europe and Australia, with clinical trials ongoing in the US – has made it possible to transplant hearts obtained from cardiac death (DCD) donors, whose circulation stops before the heart is removed. Cold storage, the most common organ-preservation method, only allows for heart transplants from brain-dead, but beating-heart, donors. "Our modelling with the NHS Blood and Transplant Authority suggests a 25 to 30 per cent increase in heart

transplant availability by using DCD hearts," says Stephen Large, lead surgeon on the first European DCD heart transplant performed at Papworth Hospital, Cambridge, in March.

Two thirds of donated hearts are currently discarded by doctors who are unsure of the organs' functionality. "Here, there is a system where you can watch the heart beating for real," Beswick says. "You can discover whether it's actually transplantable." **GV** transmedics.com

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TransMedics is giving new life to donated organs

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The Organ Care

System preserves

hearts for around

previous methods

twice as long as

REVIEWED By an ai

A scathing review is hurtful enough, but how humiliating would it be if it came from an algorithm? Here are three computer critics WIRED thinks you should worry about. GV





THE NOVELTY TEST

This creativity-assessing algorithm, designed at Rutgers University, New Jersey, scoured more than 80,000 paintings for patterns or styles that were likely to be imitated. Picasso's Les Demoiselles d'Avignon was one of the highest rated. rutgers.edu



HEMINGWAY

Inspired by its namesake's terse prose style, this app tells you if what you are writing is readable or a mess. Colour-coded highlights suggest pruning a crammed sentence, swapping complex words for simpler ones, and culling adverbs. hemingwayapp.com



THE MOVIE CRITIC

A system developed in January 2015 by Northwestern University ranked 15,425 US films by their number of references in later films' IMDb entries. It was more accurate than human critics at predicting what was in the National Film Registry.

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GROUNDS FOR SUSTAINABILITY

Arthur Kay is turning your cafètiere sludge into a biofuel to power the city



Far left Arthur Kay: "I liked the idea that in the same way coffee fuels your body, coffee can fuel buildings and transport"



RTHUR KAY SELLS COFFEE THAT CAN POWER YOUR CAR AND KEEP YOUR

house warm. The 24-year-old is the founder and CEO of bio-bean, a London-based company that transforms waste ground coffee into biofuel. Its raw material comes from hundreds of caffeine-consuming locations around the UK – office blocks, cafés, instant-coffee factories – which provide the coffee grounds for free, in exchange for being relieved of waste-management costs. Once the grounds enter

bio-bean's Cambridge factory they go through a process of sifting and drying to remove excess moisture before getting hammered by a mechanical press and mixed with an organic solvent to do away with plant oils. Most of the biomass is then compressed into pellets (*pictured above right*) that are used to heat buildings. Bio-bean is also exploring liquid biodiesel for vehicles, and other biochemicals.

Kay, a 2015 WIRED Innovation Fellow, came up with the idea while studying architecture at UCL. "My real interest was initially in collection and recycling, not biofuels," he explains. "I was thinking about how to design sustainable cities, how to fuel the city of the future." He settled for coffee waste because of the substance's heat-generating properties, and because it was available and easy to collect. "Every tonne of waste coffee grounds recycled using bio-bean's technology saves

034 / START / COFFEE BREAK / SONIC SOLUTION

6.8 tonnes of CO₂ emissions. It's like driving from London to Beijing – twice."

Bio-bean's factory can process about 50,000 tonnes of waste grounds per year. But more than 500,000 tonnes are produced annually in the UK, so Kay is working to scale up the company's operation. Right now, however, the goal is enhancing bio-bean's liquid fuel production before establishing global franchises and partnerships.

"There's nothing unique about the UK coffee market," Kay says. "There's no reason why this thing couldn't be done around the world." GV bio-bean.com

It's boom time for fire-fighting



Future fire crews might soon be taming blazes with subwoofers. Seth Robertson and Viet Tran

with subwoofers. Seth
Robertson and Viet Tran – two
engineering students from
George Mason University
in Fairfax, Virginia – have
devised a fire extinguisher
that uses sound waves to
put out flames. The Wave
extinguisher looks like a 7kg
barrel-shaped speaker which
blasts out low-pitched tones.

The sound waves stir the air and, if powerful enough and at the right frequency, can disperse the oxygen that stokes a fire. They also lower the air pressure around the blaze, reducing its temperature. "Fire needs heat, fuel and oxygen," says Tran. "Sound waves remove heat and oxygen from the source, which kills the fire."

"It was trial and error to

understand what frequency worked best with each kind of fire," Robertson says. "Now we use an infrared visor to read the wavelength of the fire and apply the right frequency."

Robertson says they are now looking into mounting their extinguishers on drones to tackle high-risk fires. "We are talking to drone companies about that right now," he says. GV gmu.edu



SONY

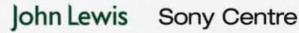




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Go Deeper



IT MAY LOOK LIKE R2-D2 BUT IT DOESN'T BELONG IN SPACE: THIS ROBOT

is a car park security guard. Created by Silicon Valley-based startup Knightscope, the K5 is designed to patrol outdoor locations and report suspicious activities to law enforcers. Every bot is equipped with a video camera, a toolkit of sensors – measuring everything from humidity to temperature – and a GPS that allows it to move autonomously around an assigned area.

"It reacts when it sees anything out of the ordinary," says Stacy Dean Stephens, Knightscope's vice president of marketing and sales. When K5 spots a person walking in a place closed to the public it will alert Knightscope, which will in turn decide whether to call the police. Available to hire for \$6.25 (£4.05) an hour, it is cheaper than a human guard and can even identify stolen vehicles through registration-plate-recognition software.

Knightscope was established in the aftermath of the December 2012 Sandy Hook Elementary School shooting. "In a crisis, you need extra eyes and ears to observe what's going on without putting humans in danger," Stephens says. These robots would do all the legwork, collecting "data to help tactical technicians deal with the situation."

The 150cm, 136kg robots are currently deployed in the car park of security company Northland Controls in Fremont, California, and further contracts have been signed for up to four dozen K5s by the end of this year. Knightscope is working on new features, such as additional sensors to detect radiation or chemicals. What they won't be fitted with is weapons. "It would become socially unacceptable," Stephens says. "Everybody is already concerned about robots taking over the world, so that's a very thick line we won't cross." GV knightscope.com

ROBOCOP WITHOUT THE WEAPONRY

K5 can patrol car parks, alert the authorities of wrongdoing and report stolen vehicles

WHITE KNIGHT / ESSENTIAL APPS / START / 039



APPS OF THE MONTH



< WIRED

THE STREAM APP

No more nagging your friends for their Facebook photo uploads: this app creates an event-specific stream, with your group's photos automatically uploaded as they are taken. iOS, free thestream app.com



PAPER FOR

The popular iPad drawing app comes to the small(er) screen, with a range of new features including text, photos and to-do lists to extend its appeal beyond artists and designers. iOS, free fiftythree.com



CRYSTAL

With Safari integration, this content blocker prevents website ads from loading, resulting in a claimed 4x increase in browsing speeds and 50 per cent reduction in data usage. iOS, free crystalapp.co



SEND

Easing the transition between email and workplace IM, this Microsoft app puts an SMS skin over Outlook's email infrastructure for communications without switching services. iOS, Android, free microsoft.com



ADDAP'

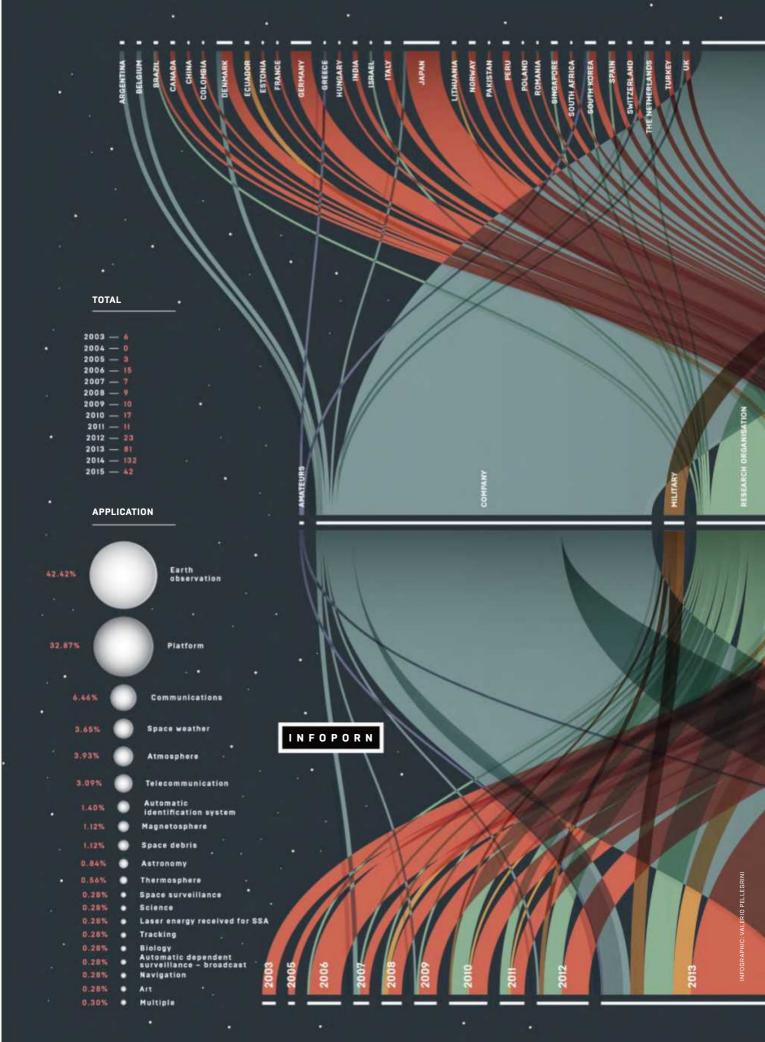
This smart contacts manager keeps itself up to date by tracking changes to your friends, family and co-workers' contact details – as long as they're addappt users. iOS, Android, free site.addappt.com



WEIRD

CAT-A-PULT

This simple-yet-difficult game challenges you to turn a random cluster of 8-bit cats into a perfectly stable circus-quality pyramid – by catapulting them on top of each other. iOS, Android, free tivola.de KN



activity – not everything is recorded openly."

A nanosat is defined as any satellite weighing 10kg or less, such as the shoe-box-sized modular CubeSats, which cost a few hundred thousand pounds to build and launch, compared to the hundreds of millions required for the traditional full-sized alternative. "It's not just universities – a huge part of this growth is driven by commercial actors selling data," explains advanced concepts lead Florian Deconinck. Companies include San Francisco-based satellite imaging startup Planet Labs (WIRED 05.15), which was responsible for 65 per cent of all satellite launches in 2014.

Despite the huge opportunities nanosatellites bring, for traditional satellite operators the idea of hundreds of new players firing things into space has raised concerns. "Imagine you've got a satellite up there worth £300 million," says Deconinck. "You're going be pretty scared that something impacts it." Part of the aim of tracking these satellite launches is to show how small a contribution they make to the amount of space debris floating around. "There are already more than 21,000 objects larger than 10cm in diameter," he explains. "It's close to half a million of less than 1cm. The total number of nanosats is tiny compared to the amount of material that's already in orbit." KN sa.catapult.org.uk



HOW WILL WORKPLACES CHANGE BY 2025?

STEWART BUTTERFIELD

CEO, SLACK

"The human relationship with information is changing. From the printing press to the internet, our ability to retain and make use of information is becoming exponentially more powerful. Just as engines and electricity gave our species unprecedented power over the physical world, so too will our ability to manipulate and exploit information make us orders of magnitude more powerful and productive. We are near the beginning. In ten years' time our physical workplaces will look much the same, but our tools will have taken another leap as large as the one from printed atlases of the world to Google Maps." GV





ROSALIND SEARLE
PROFESSOR OF ORGANISATIONAL
BEHAVIOUR, COVENTRY UNIVERSITY

"Our future workplaces will have two distinct classes. The first will be based on trust and will have more committed and engaged workers, more equality and knowledge sharing. They will have fluid and adaptable workspaces, where staff can come together and co-create. They will be learning and knowledge centres. The second group will be made up of more controlled workplaces. which will have greater use of monitoring and control, low trust and large reward inequalities. These workplaces will have greater levels of surveillance and more regimentation."



BRAD NEUBERG FOUNDER, SPIRAL MUSE

"Silicon Valley companies such as Google will integrate more into their local communities, providing public spaces and leaving behind infrastructure that raises the quality of life for everyone, not just their staff. The importance of physical offices will also decline; we are now at peak 'real office'. Collaborative tools and stronger individual and organisational skills will allow telecommuting to enter the mainstream. Co-working spaces will provide community for these off-site workers."



JEANNE MEISTER FOUNDING PARTNER, FUTURE WORKPLACE

"The workplace of the future will tap into your emotional, physical, virtual, intellectual and aspirational needs. Think of the workplace as an experience you are part of along with your co-workers, customers and partners. It will resemble your living room or your favourite pub. You will learn instantly on your wearable device. communicate with co-workers on your company app and post updates on your company's social network. This future workplace will excite, engage and entice you."



JOHN UNDERKOFFLER CEO, OBLONG INDUSTRIES

"The future of the workplace looks like an elegant, improvisational dance of people and pixels - humans and displays coming together, breaking apart and recombining. One revelation is that every task has a different physical scale related to complexity; sometimes a tablet will be enough, but other times you will need a room full of pixels. The key is a universal user interface, detached from individual devices but knowing where all the pixels are - a spatial UI."

"Bold, different and deserves to be seen by everyone."



"Astonishing, breathtaking and vastly entertaining."

Vanity Fair



"A masterpiece, plain and simple."

Stuart McGurk-GQ

michael kate seth jeff fassbender winslet rogen daniels

steve jobs

from director danny boyle and screenwriter aaron sorkin

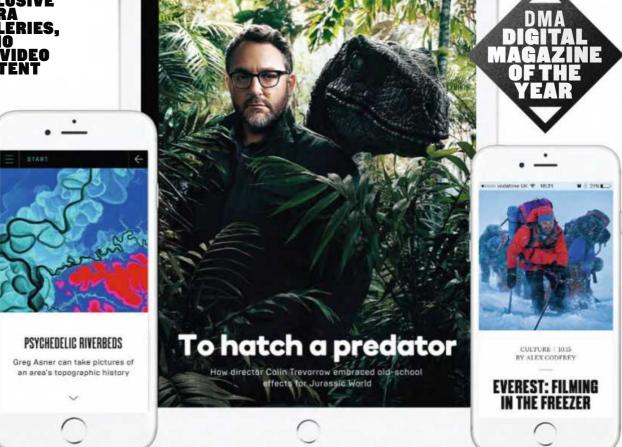
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WIRED ON THE IPAD - IPHONE + OUT NOW ON APPL

HIS BUILDING AIMS TO

cut air pollution. Designed by Rome-based architects Nemesi Studio, the Italian Pavilion at the Milano 2015 Expo is covered in a white, geometric skin. It is formed from moulded panels of i.active BIODYNAMIC, a new type of cement created by Bergamo-based manufacturer Italcementi.

"The building is like a tree or a forest," says lead architect Michele act like the leaves."

a big city that has 15 per cent of its surfaces covered by this product you can reduce the pollution by about 50 per cent." That, Italcementi claims, makes 1,000m2 of the stuff as effective as planting 80 evergreen trees.

The cement was first used on Rome's Jubilee Church in 2000, but this new, dynamic version was designed specially for the Expo pavilion. Its higher flow levels mean it can be injected into moulds, which allows for more intricate designs. To create the pavilion's complex pattern, each panel was designed in four layers using 3D software.

WALLS THAT EAT SMOG

Milan's post-Expo legacy is a breath of fresh air

After the Expo's closure at the end of October, the pavilion will become a centre of technological innovation for the city. One of the cement's ingredients is Carrara marble, just as Michelangelo used. "It speaks about the future but at the same time complies with Italian tradition," says Molè. Sophia Epstein italcementigroup.com

CEMENTINSPIRED BY NATURE

aggregates, uses titanium dioxide to give it photocatalytic



A FRAMEWORK FOR THE FUTURE OF FERRYING



INSIDE THIS HANGAR SITS

the next generation of fuel-efficient passenger hovercraft. Destined for Hovertravel's Portsmouth to Isle of Wight route, the 12000TD will the replace two 30-year-old AP-188

models which currently make 70 daily crossings across The Solent, powered by four engines apiece: two to lift the craft and two to propel it forward. The new design has just two engines per craft. "Each has a pair of integrated engines that combine lift and forward thrust," explains Paul Irvine, mechanical and system design team leader at Southampton-based Griffon Hoverwork, the company responsible for the craft.

The 12000TD is set to take to the water for testing this winter, and Neil Chapman, managing director of Griffon's sister company Hovertravel, which operates the service, expects the engines to contribute to an improvement in fuel efficiency of between five and 25 per cent. When the hovercraft launch commercially in April 2016, passengers will experience reduced cabin noise from the two engines' slower-moving propellers.

Griffon Hoverwork's R&D team is already working on its next project: a small craft suitable for rescue services. "It will be a platform for new technologies," says Adrian Went, the company's managing director. "An inflatable deck on either side will make it ideal for rescue missions." Clare Dowdy griffonhoverwork.com



The 22-metre-long craft will be able to carry 88 passengers and three crew



THERMAL IMAGE RECOGNITION - NO LONGER A STAB IN THE DARK



Researchers in

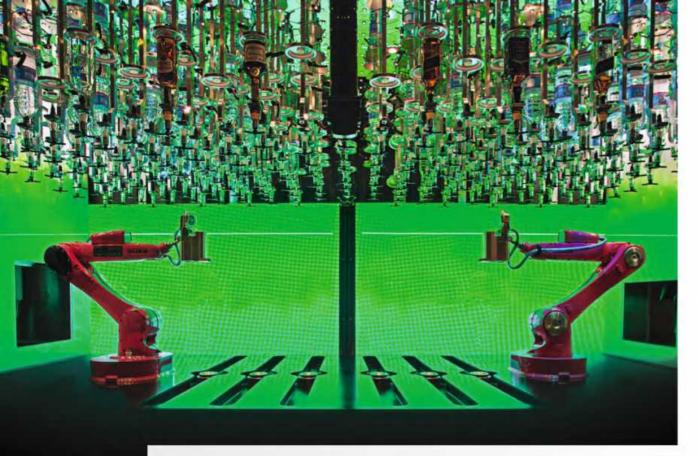
Germany have just made lurking in the dark much harder. A team of computer scientists from Karlsruhe Institute of Technology near Stuttgart used deep neural networks – a multi-layered digital imitation of human neurons – to match a well-lit photo with a thermal image of the same face.

Unlike a person's visual appearance, their thermal signature varies wildly depending on factors such as air temperature or level of excitement. The solution was "to use pairs of thermal and visible images to train the neural network", explains lead researcher Saquib Sarfraz.

Feeding the network 4,585 images of 82 people, taken both in full light and in the dark using thermal sensors, resulted in an accuracy rate of more than 80 per cent. Granted, Sarfraz explains, that kind of accuracy can only be attained if the network is provided with "four to eight normal pictures of a person". If the network has just one visible light picture, its accuracy drops to 55 per cent. Still, a handful of mugshots would suffice to identify a suspect captured by an infrared camera. "It has many applications for law enforcement," Sarfraz says. **GV** kit.edu



The 12000TD's hull is constructed from marine-grade aluminium



048 / START / TOT BOT

THEY MAY LACK A HUMAN BARTENDER'S

conversational skills, but the Makr Shakr's robotic arms can make a pretty good cocktail. "It can reproduce all the actions of a barman - from the shaking of a Martini to the muddling of a mojito, even thinly slicing a lemon garnish," says Carlo Ratti, director

of the Massachusetts Institute of Technology's Senseable City Lab where the Makr Shakr bar was developed. "Because they're robots they don't make mistakes and they're able to mix doses to millimetre precision."

Sixty spirits can be stored in the ceiling-mounted bottles, alongside syrups, sodas, juices, lemons and limes. Customers place an order through the companion app,

either choosing from classic cocktails, remixing recipes created by other users or creating their own from scratch. "It was surprising that most drinks are not the classics, but actually custom-made," says Ratti, who recently spoke at WIRED2015. "We are running quite a lot of analytics on the data – it's amazing to discover the unusual combinations that come out of it."

To avoid the aggressively sharp action of typical industrial robots that might intimidate customers, the Makr Shakr team carefully choreographed the arm's move-

ments, taking cues from analysis of the motion of Roberto Bolle, principal dancer at the American Ballet Theatre. "It was not an easy engineering task," says Ratti. "In the first prototype the robot would sometimes The *Makr Shakr* app allows customers to order from up to 10¹⁰⁰ drinks combinations

miss the cups. The interesting thing is that people would try to support it by clapping their hands."

Two Makr Shakr bars have been installed on Royal Caribbean cruise ships, and a pop-up version, packed inside a shipping container, was exhibited at the Expo Milano 2015, before heading to a private event in London this month. "We're working on several new configurations," says Ratti. "A smaller machine that could fit into a corner café, and even a low-cost one for your living room." KN makrshakr.com

THE TIP-FREE BARTENDER

MIT's Makr Shakr can fix your perfectly blended cocktail in seconds - and it will never call time



Digital extra!

Download the WIRED app to watch the Makr Shakr at work



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1. Official EU MPG test figure shown as a guide for comparative purposes and may not reflect real driving results. 2. 32 mile EV range achieved with full battery charge. 541 miles achieved with combined full battery and petrol tank. Actual range will vary depending on driving style and road conditions. 3. Demestic plug charge. 5 hours, 16 Amp home charge point is 5. hours, 80% rapid charge. 30mins. 4. Government subsidised charge points are available from a number of suppliers for a small fee – ask your dealer for more information. 5. Congestion Charge application required, subject to administrative fee. 6. 5% BIK compared to the average rate of 25%. 7. Prices shown include the Government Plug-in Car Grant and VAT (at 20%), but exclude First Registration Fee. Model shown is an Outlander PHEV GXHs at 236,499 including the Government Plug-in Car Grant and metallic paint. On The Road prices range from £29,304 to £36,054 and include VED, First Registration Fee and the Government Plug-in Car Grant please visit www.gov.uk/plug-in-car-van-grants. The Government Plug-in Car Grant flease visit www.gov.uk/plug-in-car-van-grants. The Government Plug-in Car Grant glease visit www.gov.uk/plug-in-car-van-grants. The Government Plu

Outlander PHEV range fuel consumption in mpg (ltrs/100km): Full Battery Charge: no fuel used, Depleted Battery Charge: 51.4mpg (5.5), Weighted Average: 156.9mpg (1.8), CO₂ emissions: 42 g/km.



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to Topher White (right), and he'll use it to save the rainforest. "Illegal logging accounts for 50 to 90 per cent of all logging in tropical regions," says the 33-year-old founder and CEO of San Francisco-based non-profit Rainforest Connection. "It's an immense issue, but it's really not feasible for humans to monitor large swathes of rainforest." White's solution: a cheap, solar-powered surveillance network of discarded mobiles. "Each can pick up the sound of a chainsaw from over a kilometre away and automatically transmit an alert to rangers within two minutes," he says. "That's a huge improvement over satellite imagery, which takes several days at best."

This audio data is sent to the cloud allowing Rainforest Connection to receive more than alerts of illegal activity. "We can build an archive of everything that happens in the forest 24/7," explains White. "We could say when

a family of orangutan visit, or measure the health of the forest from insect noise." The biggest challenge has been keeping the phones powered, he explains. "Normal panels are very inefficient if there's just a bit of shadow on them, but these work with 90 per cent shadow and occasional rays of light."

A project in Cameroon resulted in the confiscation of a monkey carcass and motorbike from a poacher. Half a dozen of the devices still operate in the Brazilian Amazon, helping the Tembe tribe protect their 6,000km² of rainforest - 80 per cent of which is under siege by loggers and settlers. The next installation was due to take place in Ecuador in October.

Rainforest Connection plans to allow anyone anywhere to listen in to their network. "The next thing is making it available through our mobile app, which we'll be releasing this year," White explains. "We want to be a clearing house for all the data you can get out of the rainforest." Kathryn Nave rfcx.org

DONATE YOUR OLD PHONE AND

Topher White uses discarded mobiles to listen for illegal logging and prevent poaching



JUNGLE SOUND / WTE / START / 053

WIRED Energephagy Envy button **Battling drones** Big egg Showgoers

TIRED Phycophagy **Empathy button** Battling bots Big pharma **Evening Slack**

EXPIRED Entomophagy Dislike button **Battling tops** Big oil

Livetweeting

EARLY ADOPTERS



WHAT'S EXCITING...

WHITNEY WOLFE Founder and CEO, Bumble

"I'm often too busy to read the paper or watch the news. so theSkimm newsletter allows me to stay up to date in a quick. thoughtful and light-hearted way. Starting your day with an intelligent overview of world events is important - but a little humour is good for the soul."



WHAT'S EXCITING...

SREE SREENIVASAN Chief digital officer,

Met. Museum of Art, New York

"Word Lens was a magical app that let you translate printed text by looking at it with your camera; Google bought it and incorporated it into Google Translate for iOS and Android. Now you can look in 27 languages and get translations in real time."



WHAT'S EXCITING...

SARAH T GOLD Creator. the Alternet

"Creative Commons has successfully crowdfunded Made with Creative Commons - a book about open business models. It's needed because knowing how to make a living while sharing your IP under an open licence can be confusing." GV

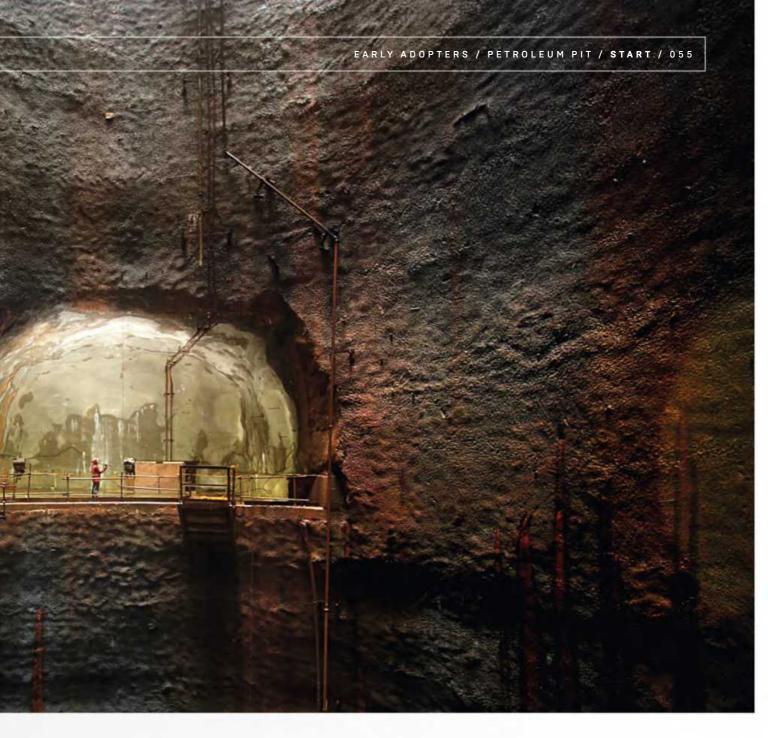


s a tiny island city-state, Singapore can't expand outwards - so it's moving underground. The Jurong Rock Caverns, being built 150 metres underneath petrochemical hub Jurong Island, will be taller than a nine-storey building and store almost 1.5 million cubic metres of oil - the capacity of 600 Olympic-sized swimming pools.

"With the limited land available, one of the best possible ways to

increase space is to create it underground," says Jian Zhao, professor of geomechanics at Monash University, who led the initial feasibility study for the caverns. Together, the five caves will create 60 hectares of space below Banyan Basin.

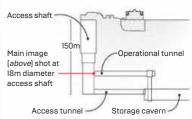
The first of the five caverns took eight years to complete, and the next four are still in the making. JTC, the local corporation tasked with their development, hopes to complete the project by the end of 2016. Each of the caverns, and the 9km of access tunnels built around them, were drilled and cleared using



explosives, then lined with cement and finally stabilised with bolts anchored into the rock. To prevent any of the hydrocarbons leaking into the rock walls, a series of water-filled tunnels and boreholes were built around the caverns; this "water curtain" keeps the caverns sealed through hydrostatic pressure.

This is not the country's first underground endeavour. "Singapore has already built one of the most advanced underground ammunition facilities in rock caverns," says Zhao. Some roads, the metro system, sewage treatment and transport facilities are also housed underground. Next are plans for underground power plants, sports stadiums and even libraries. "The government

has launched a 130m Singaporean dollar (£60m) R&D programme called National Innovation Challenges: Land and Liveability – and one of the focuses is on creating underground space for better urban living there," says Zhao. "Singapore is leading the world on exploring underground space as part of the urban development." Sophia Epstein jtc.gov.sg



JURONG'S MAN-MADE CAVE SYSTEM

HOW TO PUT OIL BACK IN THE EARTH

Singapore is digging deep to store its hydrocarbon stockpile



A SHOCK TO THE SYSTEM

YOUR SMARTHONE MIGHT NEED A PROTECTIVE CASE, BUT THE G-SHOCK MT-G SERIES IS TOUGH ENOUGH TO HANDLE LIFE IN THE WILDERNESS – AND THE OFFICE

Toughness and strength needn't come at the expense of style. The new MT-G G1000D (*left*) exemplifies G-SHOCK's approach to premium watchmaking, with a sleek, brushed steel case and Triple G Resist construction that's built to withstand shock impacts, vibration and gravity resistance.

The MT-G is designed to always keep its wearer on time, no matter where they are in the world. The combination of GPS and terrestrial radio technology means the MT-G automatically knows what time it is – even if you don't – and updates itself.

That feature is coupled with Dual Dial World Time, which simultaneously shows the current time in two different zones at a glance.

All that tech is protected by a metal framework linking the bezel and the back cover. This structure, unique to G-SHOCK, protects the module – the working elements – from direct impact by allowing it to essentially float within the structure.

Designed and built in Japan by Casio, the MT-G G1000D is one watch that's smart, stylish and solid. Available at Ernest Jones. For more information see g-shock.co.uk

The first G-SHOCK was released in 1983 to the specifications of Casio's Kikuo Ibe. The range was built on his motto: "never give up" - a phrase that reflects the brand's pursuit of innovation and hard-wearing design.

200M WATER RESISTANCE

SOLAR POWERED

The Casio Tough

Solar recharging

system can utilise sunlight, as well as light from fluorescent lamps

and other sources.

The discreet panel

isn't visible on the

watch face.

The sealed outer case of the G-SHOCK MT-G G1000D means it is waterproof down to depths of 200m. Ideal for swimmers, divers and even outdoor adventurers of every kind.

G-SHOCK PREMIUM RANGE



MT-G S1000D-1AER

With red accents on the watch face, this model has a core guard structure and is crafted from resin and stainless steel. Framed by a sallaz-polished bezel with a scratch-resistant sapphire glass for optimum durability, it's suitable for everyday and smart occasions.



MT-G S1000V-1AER

The aged ion-plated black of this watch echoes special ops kit. The side buttons, crown, dials and the hour and minute hands are silver. The hour markers, which are made of resin for shock resistance and light weight, are coloured using a nano-level process.



MT-G S1000BD-5AER

This rose gold and black watch has a metal bezel and back cover to create a frame that houses its inner workings. This reduces the chance of impact-force reaching the watch's module. In addition, a gel is used at points of contact on the bezel and cover to further absorb impact.



VAUXHALL ADAM EVERY onès an original

Official Government Test Environmental Data. Fuel consumption figures mpg (litres/100km) and CO₂ emissions (g/km). ADAM S 1.4i 150PS Car shown is ADAM S 1.4i 150PS Turbo in I'll be Black with Red n Roll roof colour pack and Morrocana Recaro seats.



Design your very own unique ADAM from a palette of 19 body colours, 7 roof and mirror colours and 25 alloy wheels. There's no end of combinations of exterior and interior accessories and trims, and hi-tech gizmos galore. **Go create at Vauxhall.co.uk/ADAM**

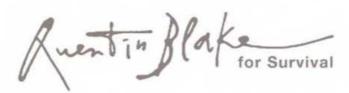




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HERE AREN'T MANY

startups that manage to raise more than \$100 million (\$65m) from investors before reaching their first birthday. Even more rarely do they use that money to buy a factory that's almost a century old. But that's exactly what Harry's, a New York-based barbershop and internet razor vendor, has done. The chosen site: that of 95-year-old razor manufacturer Feintechnik GmbH in Eisfeld, Germany.

What could an online retailer want with an old factory? "Strategic planning," says Frederic Handt, managing director of Feintechnik. There are only a few factories worldwide that can manufacture razor blades - the machines are highly specialised. Thanks to the purchase, Harry's now controls the entire production chain, "from the research department to the customer," explains Handt. With over 1.3 billion blades per year currently being produced by Feintechnik's furnaces, that might concern even market leader, Gillette. "Our people work around the clock," explains Handt. "The ovens need to remain at optimal temperature." Tim Rittmann harrys.com



SCALING UP A VERY SMOOTH OPERATION

Our series on tools visits a cutting-edge factory making razor blades by the billion

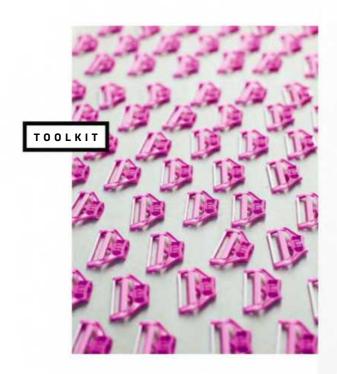


PUNCHING

The wafer-thin metal is shaped for further processing and incorporation into the blade housing.

нот то соср

The blades are heated up to 1,100°C, then cooled down to minus 70°C. The process is called "stressing out" and is done to temper the metal, so that it hardens, but doesn't become brittle.



LUBRICATION

A lubricating strip with vitamin E and aloe vera is added to ensure that contact with the blade doesn't irritate the skin.

ASSEMBLY

Under inert gas and heat, a protective coating is bonded to the cutting edge – this process is called sintering.

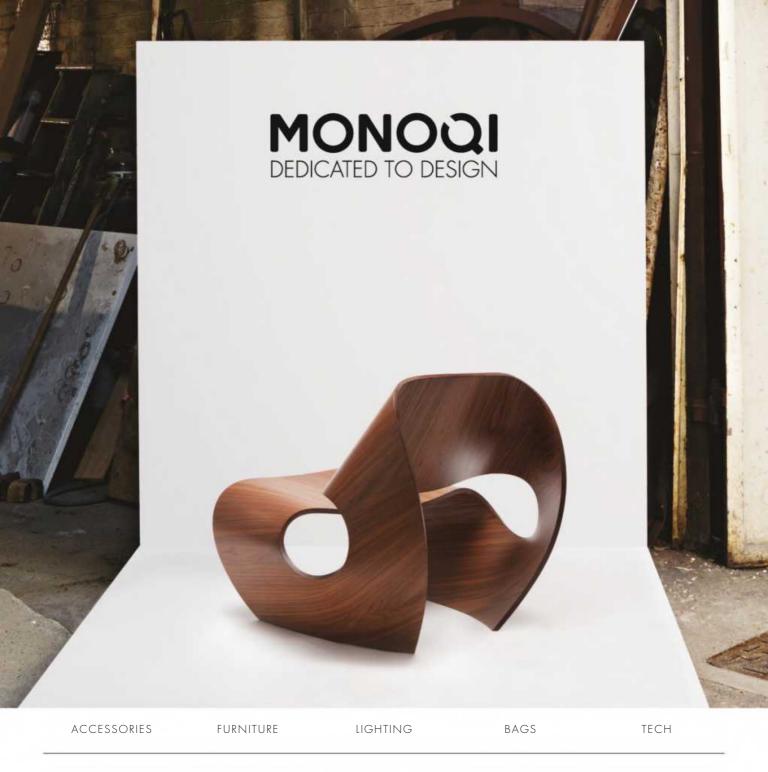
WORKERS

Around 450 people work around the clock on the machines. They work in four shifts: six days of work, two days off.



062 / START / SHARP THINKING















 $\label{eq:Register now at MONOQl.co.uk} \text{ and discover handpicked design from around the world every day}$



THE WATCH GALLERY.

CURATORS OF THE WORLD'S MOST EXQUISITE WATCHES

Investing in a luxury watch can often seem as complicated as the micro-mechanics ticking away inside it. The Watch Gallery and its finely tuned team of online experts allow it to be an effortless experience. Here is a retailer that has assembled an enviable collection of luxury brands whilst remaining focused on the models that matter. The website embraces the brand's entire knowledge base with a live-chat function, meaning you can liaise directly with an expert, to help guide you through your purchase. For more information and to view the full product portfolio, visit www.thewatchgallery.com











FUTURE CITIES

WE'RE LIVING THROUGH AN ERA OF RAPID URBANISATION. BUT HOW DO WE MAKE SURE THE CITIES WE CALL HOME GROW SUSTAINABLY, RESPONSIBLY AND WITH THE FUTURE WELL-BEING OF CITIZENS TAKEN INTO CONSIDERATION?

"One day, I think historians will refer to the period of 1950 to 2050 as the century of the city," says Shell vice president global business environment, Jeremy Bentham. "Urbanisation is one of the greatest social phenomena of our times. And sometimes, in the west and the advanced economies – which have been pretty highly urbanised for a long time – we forget that."

Research shows that more than half the world's seven billion inhabitants lived in cities in 2007. By 2050, about three-quarters of us will, as the population grows from seven to nine billion. By then, urban infrastructure

equivalent to a new city of more than 1.4 million people will have been built every week. The greatest growth in urban population will be in China, India, the US and sub-Saharan Africa – particularly Nigeria.

With more of us living in urban areas every year, we need smart energy ideas in action to deal with the issues that emerge from city growth, such as energy demand, congestion, emissions and population density, to name just a few.

To help imagine how the world of today will develop tomorrow, Bentham oversees a team who work on scenario-development projects

that combine in-depth research and futurism to "help stretch and extend the thinking of Shell decision executives," he says.

One of these "memories of the future", as Bentham refers to them, entitled New Lenses on Future Cities, deals specifically with the issues surrounding urban development in all sorts of different environments, countries and continents.

"We've learned that city development patterns are key drivers of future demand for energy and other resources. So clearly that's one of the elements we want to grapple with in our understanding of urban development. If you're going to understand energy demand, you have to understand urban development."

One of the clearest takeaways from the Future Cities research – which was undertaken in partnership with Singapore's Centre for Liveable Cities – is that compact cities, such as Singapore and Hong Kong, are generally more energy-efficient and produce fewer emissions than sprawling cities like Los Angeles, for example.

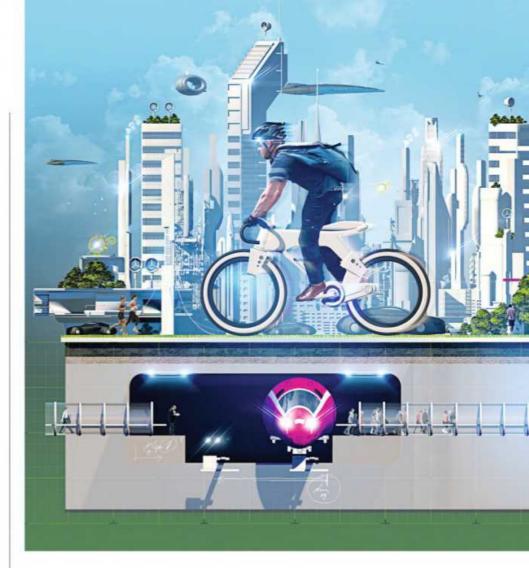
"If you compare the energy use per capita for personal transport, the United States uses three times as much energy as Europe," says Bentham. "Part

of that is because Americans tend to have bigger, heavier vehicles on average, but the main reason it is that they travel twice as far as Europeans."

Other factors will also impact whether a city works well economically – for us as citizens, and for the environment. Bentham's team at Shell have highlighted five areas that, if successfully implemented, can lead to positive, well-managed urban growth. And, if bungled, can potentially cause problems for a city's future and its citizens.

The five factors that lead to what Bentham calls "room to manoeuvre" include flexible long-term planning, investment in the future, the ability to build trust, the capacity to implement projects and public/private collaboration.

Singapore has shown how these factors can be successfully managed. In the 60s, a quarter



"IF YOU'RE GOING TO UNDERSTAND ENERGY DEMAND, YOU HAVE TO UNDERSTAND URBAN DEVELOPMENT"

of the 1.6 million population lived below the poverty line. A quarter of a million people lived in city centre slums – and even more in squat areas. Public hygiene was poor and malaria and tuberculosis widespread. Unemployment rates rose from five per cent in 1957 to 14 per cent 1959.

However, through measured reform the city turned its fortunes around. In the following decades, several iterations of major urban planning initiatives were updated to take into consideration unexpected population growth. Restrictions on the use of cars in the city centre were imposed and investment in public transport improved mobility. And, to create enough housing, red tape was slashed and strong landacquisition laws and powers of resettlement enacted. By the mid-60s, Singapore could build the equivalent of one flat every 45 minutes.

In 2015, the World Happiness Report by the United Nations reported that Singapore was the highest-ranking country in Asia in terms of the happiness of the people who call it home.

London is often praised for its ability to move with the times and remain a thriving global city. So does it adhere to Bentham's list of factors that might give it room to manoeuvre?

In terms of flexible, long-term planning, the city mayor, Boris Johnson, recently published several reports on the capital's future, including the London Infrastructure Plan 2050 – A Consultation. This detailed document summarises how City Hall intends to deal with population growth, incorporate new technologies and innovation, manage infrastructure and resources, upgrade its transportation systems and much more. The takeaway is that London is looking to the future.



Investment in the future is underway and represented by extensions to the Tube network, 200km of new cycle highways, and a plan to make London the first capital city in the world to deploy 5G coverage.

In terms of trust, the fact that international businesses and citizens alike flock to the city is evidence of that.

London also has a history of implementing large-scale projects. Current difficulties surrounding potential airport extensions aside, the London 2012 Summer Olympics is widely seen as having been a success. Crossrail, the largest addition to the rail network of southeast England in 50 years, is due to launch in 2018 and 2019. And in July 2012, The Shard – Europe's tallest building – was completed. Many of these are collaborative projects that bring together civic discourse, global business, and government or City

Previous page and above: how London may look in 2050 if it continues to grow at the same pace as the last three decades Hall backing. The future's looking bright for this very old global city.

But what about cities elsewhere? One recent report from Shell is entitled Challenges & Opportunities for Marikina City - a study of a small city on the outskirts of Manila in the Philippines. The partnership aims to understand its situation, future challenges and energy needs through a series of workshops studying population and demographics. It seeks to identify key constraints and concerns, as well as aspirations of the city. Finally, it brings together global expertise and local knowledge to create a set of options to help the city to tackle the energy and transport challenges it faces.

The conclusion of the report suggests the development of a resilient, green, clean-power distributed energy system that works in combination with the existing grid; boosting of the aesthetic appeal of the city's river; and using green infrastructure projects to bolster flood defences. It also proposes efficient transport systems that could run on the new energy platform.

Together, the report concludes, these options could help Marikina reach its aspired vision.

That's not the only partnership Shell has forged. In China, it has a two-year agreement with the Central Government's think tank, the Development Research Centre under the Chinese State Council, to undertake studies into the country's mid- and long-term energy strategies.

And, of course, Shell is a leading innovator in natural gas. A fuel that can be liquefied to provide an economical fuel for power generation. Replacing coal-fired power stations with gas technology could cut power plant CO_2 emissions by 90 per cent, if combined with carbon capture and storage (CCS).

But ultimately, the success of our future cities around the world depends on collaboration across all aspects of society that works for the benefit of all of us – and the planet we call home.

For more, see #MakeTheFuture

TOOLS TO BUILD FUTURE CITIES



ROOM TO MANOEUVRE

Shell and the Singapore Centre for Liveable Cities conducted a series of workshops to explore what conditions lead to cities having room to manoeuvre when faced with an emerging crisis.



FLEXIBLE LONG-TERM PLANNING

Circumstances change
- and urban planning
decisions taken in the
present need to build
in sufficient capacity to
adapt and evolve
to reflect future
realities, technology
trends and stresses.



INVEST IN THE FUTURE

Just as good companies continue hiring in an economic downturn to ensure a pipeline of future talent, cities that want to keep ahead will continue to invest in education, capacity and innovation bubs.



ABILITY TO BUILD TRUST

Cities that attract businesses and citizens to settle provide a stable environment for them - consistency in rules and regulation, no sudden changes to these, and a sense of fairness for all involved.



COLLABORATE EFFECTIVELY

All sections of society have to work together if the problems associated with cities' growth are to be addressed. That includes government and the public and private sectors.



CAPACITY TO IMPLEMENT

Successful cities are not only able to design the proper policies or planning systems, but are highly effective in implementing these measures using a mixture of people, goals and support for projects.



















MYRUN TECHNOGYM® improve your running









ENKO RUNNING SHOES

Each Enko shoe comes with two coil-sprung shock absorbers with 2cm of travel, to deaden impact, conserve energy, then release it progressively as you lift your heel, to give your stride an additional boost. The springs are

to allow for fluctuations in the runner's weight, and each is guaranteed for over a million "cycles". €359 en.enko-running-shoes.com



650cm

HEIMPLANET NIAS TENT

Supported by Heimplanet's inflatable diamond grid (IDG) exoskeleton, this $10m^2$ tunnel tent can be constructed in a single inflation process. A pair of

removable cabins
offer flexible
accommodation
for up to six people,
or a combination
of sleeping space
and equipment
storage. The
exterior fabric

is available in
Heimplanet's new
Cairo Camo design
– a geometric
camouflage
print inspired by
traditional Arabic
patterns. €900
heimplanet.com



The shoe has switchable modes for running and walking

PARROT HYDROFOIL DRONE NEWZ

When attached to this trimaran hull's vertical mount, the Parrot mini-drone's four rotors effectively transform it into an airboat, propelling the combined vehicle across water at speeds of over 9kph,

with up to 6cm of elevation on its three hydrofoils, permitting impressively tight turns. When detached from its hull, the mini-drone can fly at 17kph for seven minutes per charge. £140 parrot.com

TTROBOTIX SEAWOLF

Opening up ocean exploration to those lacking James Cameron's deep pockets, the SEAWOLF ROV comes with a waterproof GoPro mount, allowing it to livestream video for first-person-perspective

On detecting

an emergency,

out the ballast

tanks to float

the SEAWOLF bails

the 10m maximum depth rating may not be sufficient to probe the floor of the Mariana trench, its 5,000-mAh battery will provide ample time to scope out the local reef – around 50 minutes. \$999





TAYLORMADE DADDY LONGLEGS 2.0

Constructed from 16 individual pieces in eight materials - including stainless steel and polycarbonate the Daddy Long Legs 2.0 golf putter delivers an extremely high moment of inertia (MOI) to resist twisting at impact. Taylormade claims a 60 per cent improvement in stability over conventional putters. £169 taylor madegolf.co.uk

WORDS: KATHRYN NAVE. PHOTOGRAPHY: SUN LEE; DAVE LIDWELL





YAMAHA REFACE

The Reface range of keyboards based on classic Yamaha synths packs a lot of sonic history into each 1.9kg model. The white CS offers an eightnote polyphonic configuration; the grey DX a fouroperator FM engine; the black CP lends a 70stinged electric piano sound; and the red YC delivers five vintage organ modes. £347 yamaha.com





CANON ME20F-SH

Offering a classleading ISO of 4.56 million - ten times the previous ISO record - the ME20F-SH is the closest you can get to a fullcolour night vision camera. Its relatively slight frame, HD video capture and remote control capability makes this ideal for nocturnal wildlife recording. \$30,000 canon.co.uk

NOKIA OZO VR

The veteran mobile-phone manufacturer is rebranding itself as an innovator in digital media solutions, starting with this nodule-laden virtual reality camera. The OZO features eight lenses with 2K x 2K sensors, synchronised

global shutters and integrated microphones with directional audio capability. There's also a handy real-time preview function accessible via any headtracking VR goggles. €tbc ozo.nokia.com



MIKME

With a gold-plated condenser capsule (alongside 24-bit audio resolution and a maximum sampling frequency of 96kHz), this onetouch handheld microphone lets you capture studio-quality sound from any source. Its internal 16GB memory can handle up to 360 hours of audio capture, with all recordings automatically backed up via Bluetooth to an iPhone. \$249

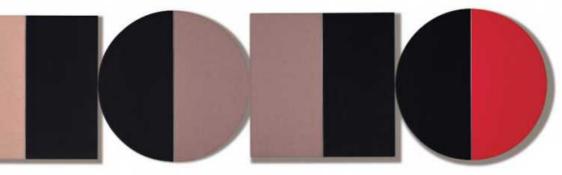
mikme.com



OMA IRONIC Cast from hypoeutectic grey iron - a material favoured for its vibrationresistant properties - the Ironic speaker's open baffle design would be unachievable using traditional casting methods. The mould for each speaker is 3D-printed in sand before perishing during the casting process, so no two pairs will be exactly the same. \$95,000 oswaldsmill audio.com

ARPER PARENTESIT

Available as a circle, square or oval, with a wide range of mono- or bi-chromatic colour options, Arper's acoustic panels combine to create a modernistic wall decoration while reducing extraneous background noise to enhance concentration. Each panel can be also integrated with a concealed wireless speaker or ambient light source. From £584 arper.com





SONY HUIS

The inaugural winner of Sony's First Flight crowdfunding project, this minimalist remote pitches itself as the only one you'll ever need. Just point any controller (TV, hi-fi, lighting) at the HUIS's receiver and it will take over operating duties. The E Ink screen shows a suitable interface for each of your devices, but can also be customised to display only buttons you want. ¥23.000 firstflight.sony.com

KATHRYN NAVE. PHOTOGRAPHY: SUN LEE; DAVE LIDWELL

laptop or TV. £tbc ikonfurniture.co.uk

sound system

with integrated



tungstenfilament bulbs under-represent the colour blue and skew red. Fluorescent tubes emit

Conventional

only scattered fragments of the spectrum. Philippe Rahm has created a custom lighting configuration designed to

satisfy both the psychological needs of humans and the photosynthesis requirements of your plants. €tbc artemide.com

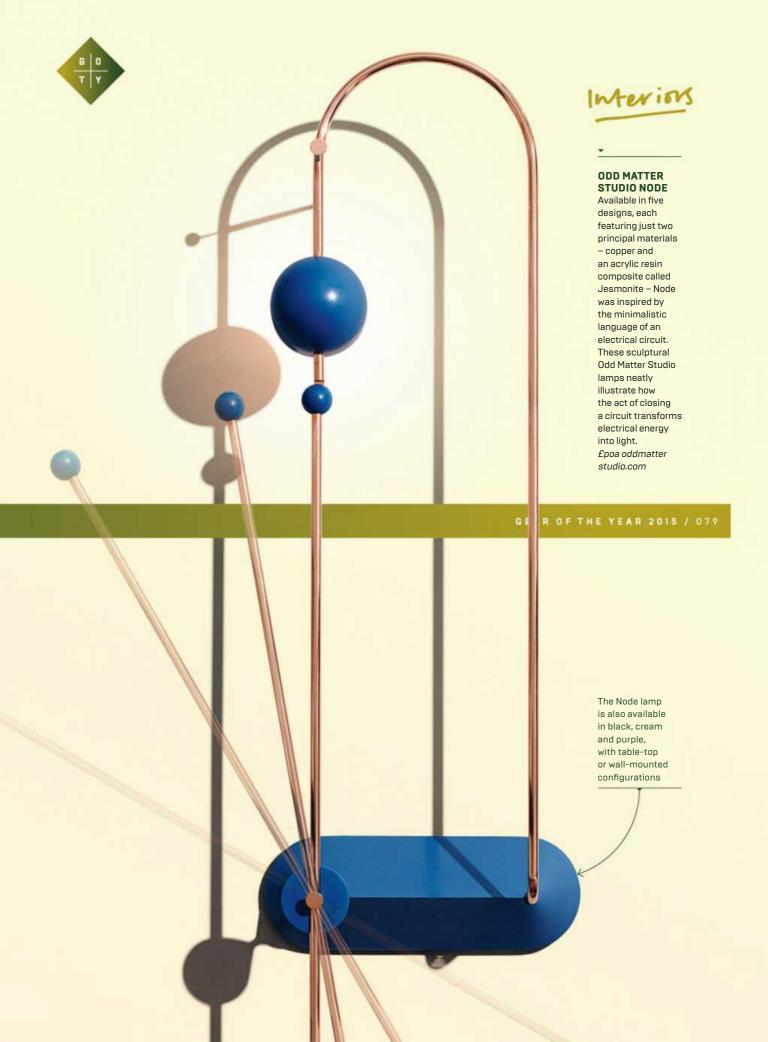


STUDIO AYASKAN GROWTH

The novel, origamibased geometry of Londonbased designers Begum and Bike Ayaskan's polypropylene flowerpots allows them to grow as your plant does. The CNC-milled tessellatingtriangle pattern allows the pots to expand by up to five times their original size, providing ample room for a growing root base while avoiding the need for regular re-potting. £tbc ayaskan.com



Flat sheets of polypropylene are welded to form expandable pots







AUDEMARS PIGUET ROYAL OAK PERPETUAL CALENDAR

Exemplifying this year's vogue for perpetual calendar complications, Audemars Piguet's latest Royal Oak design now models a larger 41mm dial, with day, date, astronomical Moon phase, month and leap-year indicators. In addition. the weeks of the year are indicated via an outer chapter ring with corresponding central hand. £48,100 audemars piguet.com

TEMPUS MACHINA RED DEPTH 216A

Inspired by the sought-after 6538 Bond Submariner, Tempus Machina has taken the newer 114060 model and reshaped it with a coinedge-teethed bezel topped with a distinctive. porcelainenamelled red triangle marker. Elsewhere, the old-stock 8mm

Brevet crown has been shorn of its crown guards, with the overall design complemented by a custom antireflective sapphire high dome – the only non-Rolex component. \$25,000 tempus-machina.com



VECTOR WATCH

Battery life remains the Achilles heel of smartwatch design - followed closely by their wearability. The Vector tackles both issues head on, claiming 30 days' use on a single charge and offering a simplified, bespoke OS with three physical buttons preserving its classically unobtrusive aesthetic. Available in either round or rectangular form factors, it has a hardened-mineral monochrome LCD screen and water resistance to 50m. From £169

vectorwatch.com

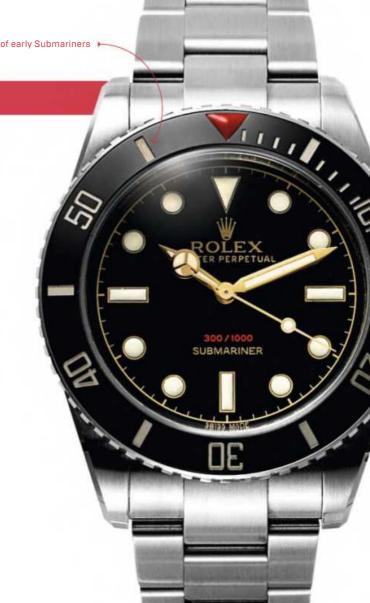
RICHARD MILLE RM69 EROTIC TOURBILLON

An evolution of those rare automatons depicting animated sexual tableaux on otherwise genteel timepieces, this design uses three titanium rollers to display a randomised suggestive message at the touch of a button. A secondary pusher retracts the hands to afford the message more impact, €591,500 richardmille.com



SWATCH TOUCH ZERO ONE

Watches seldom get more niche than one designed exclusively for participants - and fans - of beach volleyball, yet the Touch Zero One is also Swatch's first mass-produced smartwatch. A curved, backlit touchscreen offers fitness tracking. Other functions include a crowdapplause counter and a way to measure the power of your volleyball smashes. From £85 swatch.com



CREOPOP PEN

With a range of glittering, glowin-the-dark and aromatic inks available in 24 colours, this 3Dprinting pen gives the novelty of scented gel pens an added dimension. Rather than relying on melted plastic, the CreoPop's tactile ink is made from photopolymers solidified by LED diodes, thus eliminating any dangerous heat or unpleasant odours. From \$119 creopop.com





TECHNOLOGY WILL SAVE US DIY GAMER KIT



This Arduinobased open-source kit is the perfect introduction to the fundamental workings of gaming systems. A simple 64-pixel LED matrix display provides the backdrop for two pre-installed lo-res gaming classics, Pong and Snake, although users are encouraged to code their own creations. An infrared transmitter allows multiplayer mode. From £65 techwillsaveus.com

LEGO TECHNIC MERCEDES-BENZ AROCS 3245

Assembled from 2,793 individual pieces, this is the largest LEGO Technic model produced to date. It's also one of the most realistic, thanks to fully independent suspension and a pneumatic cranecontrol system. And when you tire of it, you can rebuild it into an articulated construction truck. £170 lego.com



ANKI OVERDRIVE

The original Anki Drive system featured artificially intelligent cars controlled via a smartphone app. Now there's OVERDRIVE, with its magnetic modular vinyl track – and scope for eight unique configurations using the starter kit alone – alongside a range of additional packs for extra expansion potential. £150 anki.com

NERF RIVAL ZEUS MXV-1200

The larger of Nerf's newly unveiled Rival blaster range, the Zeus MXV-1200's motorised flywheel mechanism claims a muzzle velocity of just under 113kph and the ability to empty its 12-round, ambidextrousrelease magazine as quickly as you can squeeze the trigger. Improved firing accuracy comes courtesy of the Rival's Zeus's re-engineered ball-shaped ammunition. \$50 nerf.hasbro.com







ARGO 8 X 8 XTI

With eightwheel drive, an optional caterpillar track and tripledifferential ADMIRAL steering transmission, this amphibious four-seater is engineered for the most demanding of offroad cargo hauls. The 748cc liquidcooled, V-twin Kohler Aegis engine delivers speeds of up to

compensates for the decrease in horsepower

27kph on land, and
5kph in the water, and the fully water-sealed hull benefits from a ground clearance

of 22.8cm. \$poa

argoatv.com



JAGUAR F-PACE

Developed from the award winning C-XI7 concept vehicle, Jaguar's first foray into SUV production mixes the brand's sports-car heritage with a

A 75kg reduction

in engine weight

spacious, familyfriendly interior. All driver information and entertainment options are taken care of using Jaguar's InControl Touch Pro system,

which includes a laser-projected heads-up display, an eight-inch touchscreen and a Wi-Fi hotspot for up to eight devices. From £34,170 jaguar.com





FRAUSCHER 747 MIRAGE AIR

Retaining the original 747's hull with twin, carbon-fibre air intakes created by hydrodynamics expert Harry Miesbauer, Frauscher's new Air version introduces an open bow design with a central cockpit for ample

relaxation space. Engine outputs range from 230hp to 430hp for a top speed of 56 knots, and an optional bow thruster provides extra control when mooring in a tight spot. From €159,600 frauscher boats.com



7.47m

MORGAN EV3

Morgan's iconic three-wheeler has been reinvented courtesy of a 45kW rear electric motor, making it the Worcester-based manufacturer's first production electric vehicle. The top speed is limited to 129kph with a range of 241km. The electric port - through which the car recharges within four hours - is concealed beneath the retro-styled petrol cap. The model is expected to go into production at the end of 2016. £tbc morganmotor.co.uk









collaboration. A combined hatstand and desk offers a sense of personal space in the most compact work environments, and the marble desk tidy includes a flower vase to emphasise the importance of aesthetics alongside pure function. The Teknion range also includes water carafes and twoseater chairs. £tbc pearsonlloyd.com

PEARSON-LLOYD TEKNION 2015



The beechwood tablet stand is a nod to the changing face of office workstations

ASUS RT-AC5300

Dual 5Ghz Wi-Fi bands offering up to 4,334 Mbps, alongside a 2.4Ghz band at 1,000 Mbps, make this the fastest Wi-Fi router on the market, with a total bandwidth of 5,334 Mbps. The aggressivelooking eightantenna design

musters a signal range of up to 500m², and the Smart Connect system automatically selects the fastest available frequency band for each device. £tbc asus.com



PANASONIC TOUGHPAD 4K UT-MA6 With an Intel Core i7 vPro CPU and an NVIDIA Quadro K1000M graphics card encased in its hardened glass fibre shell, this

high-performance tablet is solid inside and out. Its 4K screen can detect up to ten fingers simultaneously, and the included

electronic touch

pen is single-

pixel accurate.

£4,067 business.

panasonic.co.uk

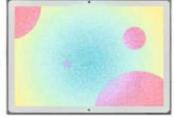


ROSS GARDAM AURA DESK LAMP

Created by Australian lighting and furniture designer Ross Gardam, this desk lamp is precision-milled from aluminium. before being goldanodised. A clever magnetic joint allows the shade to be fully rotated 360 degrees and

tilted to create more direct illumination. The gold version is limited to just 25 individually numbered pieces. A\$2,850 ross gardam.com.au

The UT-MA6 runs Windows 8.1 Pro. It has a 20in display, weighs 2.54kg and is 12.5mm thick











Let the sound surround you

It's time for your home entertainment system to get as smart as the rest of your life. BeoLink Multiroom from Bang & Olufsen links all its audio-visual devices to a single wireless system. That means you can play different music in multiple rooms, or let one track fill your home.

New touch-sensitive products allow for single-touch controls that instantly join the music stream. You can even control your entire audio experience from your mobile phone, using the *BeoMusic* app.

television into the experience, so you can use the speakers on your Bang & Olufsen TV to listen to music, or send the sound from the TV into another room's speakers.

Don't worry if you've got a classic Bang & Olufsen system. The BeoLink Converter means even previous generations of speakers and devices can be connected to provide the full BeoLink Multiroom experience.

Finally, BeoLink Multiroom means your home audio experiences can be as diverse as your taste in music For more, see hang-olufsen.com



BeoLink Multiroom allows exceptional wireless sound to flow throughout your home

THE MULTIROOM MIX





The BeoLab 18 acoustic lens distributes sound evenly through the room in a 180 degree arc. The conical base is crafted from a single tube of raw aluminium. And setup requires just a single power cable to each speaker.

The BeoSound
Essence requires
a single touch
to launch and
control your
music. Working
with the BeoLink
Multiroom
experience, you
can play different
music in several
rooms, or let the
same music fill
you home.





BeoSound
Moment is a
smart, wireless
music system
that integrates
your music
and streaming
services. With
just a touch of
the solid wood
interface, you can
launch a highperformance
sound experience.

The BeoVision Avant TV is available in 55-, 75- and 85-inch models. Compatible with BeoLink Multiroom, you can link with the BeoSound Moment and speakers to create audio/ visual heaven.





The BeoLink app enables you to close curtains, dim lights and adjust music, using just your smartphone. It controls all BeoLink systems – including audio, video, lighting and curtains, all at the touch of a smart screen.

The BeoPlay A9 might look more sculpture than speaker, but the wireless system plays excellent-quality audio via AirPlay, DLNA or Bluetooth. It links to Spotify Connect, Deezer and TuneIn as well as other BeoLink devices.



WIRED Retail

Together with

valtech_

November 23, 2015 London

For more information and to book your ticket now: wired.co.uk/retail15

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Bringing the WIRED world to life

The 20+ Main Stage speakers will include: William D

McMaster Head of VR, Visualise McMaster is pioneering 360-

degree video and will speak on the future of virtual reality.



Paul Clarke Dir. of technology, Ocado Technology Clarke is designing

Ocado's next automated fulfilment centre and moving the company's services to the cloud.



Jo Bertram Regional general manager UKI & Nordics, Uber

WIRED's one-day event exploring the digital disruption of retail

is back for a second year. Hear from more than 20 Main Stage speakers, plus 15 startups, and discover the future of commerce

> Bertram will speak on the lessons learned from Uber's staggering success.



Jessi Baker Founder, Provenance Jessi Baker's

Provenance uses the blockchain to verify products and their manufacturing processes.



Ken Denman President & CEO. **Emotient** Denman explores

how facial recognition and sentiment analysis could turbocharge customer service.



Stefan Siegel Founder & CEO, **NOTJUSTA LABEL** Siegel creates

extraordinary retail experiences, bringing pop-ups and established brands into the digital age.





Bram de Zwart Co-founder & CEO, 3D Hubs de Zwart will

address how the retail supply chain will be transformed when mass production goes digital.



James Aligrove Head of UK growth, Stripe Stripe makes the

phone the transactional device. Allgrove will explore how that will change customer behaviour.



Robert Gentz Co-founder, Zalando Gentz will explain how Zalando's radical agility is allowing them to help retailers innovate.



Sebastian Siemiatkowski Co-founder & CEO, Klarna

Siemiatkowski will talk about micro-payments and monetising customer loyalty.



James Crawford Orbital Insight Crawford will discuss

how satellite and drone imagery is impacting retail – for example, by monitoring supply chains.



Si Brown Co-founder & CMO, skignz skignz is an

geolocation-based AR platform. Brown will explain how AR could play a role in the future of retail.



Cristian van Tienhoven Senior manager, Amazon Merchant Services

van Tienhoven will explain how behaviour analysis can help build trust for consumers and retailers.



Steve Callanan CEO & co-founder, **WIREWAX** WIREWAX enables

its users to create "shoppable" videos - Callanan will give insight into this future retail format



SPECTACLED BEAR. Tremarctos ornatus. FACING EXTINCTION.

The extinction of Ecuador's rarest species is just too much to bear.

In a remote and unique habitat, engulfed in a near permanent blanket of fog, rare and magical mammals like the spectacled bear and the mountain tapir make their homes. Flourishing alongside them are forests of micro orchids, some of the world's tiniest plant species, which can only survive in the conditions particular to these locations.

Defending these extraordinary forests, and the plants and animals that rely on them, is a shared vision for international charity World Land Trust and its Ecuadorian partner, the charity Fundación EcoMinga. Since 2007 the two organisations have been working together to buy parcels of land, bit by bit, acre by acre, to create nature reserves to secure the future of known species and those yet to be discovered.

Recent reports show that a cluster of properties in the Andean cloud forest have come on to the market which is exciting news. The properties are close to existing reserves and a priority for protection, but time is short: World Land Trust urgently needs £500,000 to save these areas and the species they shelter.

Donations will make a real difference to the world's remaining cloud forests, preserving them as a permanent safe habitat for all the species – great and small – that depend on them for survival. The future of these fragile ecosystems is in our hands, and we can act together to save them today.

For more information please call 01986 874422 or visit *www.worldlandtrust.org*, for instant donations please text LAND12 to 70070 to donate up to £10.



[&]quot;The money that is given to the World Land Trust, in my estimation, has more effect on the wild world than almost anything I can think of."

F

our hundred thousand people die in

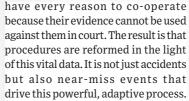
America because of preventable medical error. Note the key word in that last sentence: "preventable". These mistakes don't need to happen, shouldn't happen. But they do, over and over again. Avoidable medical error is the third-biggest killer, after cancer and heart disease. It kills way more people than traffic accidents.

The numbers are equally shocking in the UK, France and beyond. Why is this suffering happening on such a large scale? The answer is simple to state but complex to address: it's the inability to learn from mistakes. Clinicians spin their errors. They cover up. They use euphemisms to pull the wool over the eyes of grieving families.

This is not just about avoiding litigation. Evidence suggests insurance premiums go down when doctors are open and honest with patients and their families. No, this is a deeper pathology. It is the difficulty that talented, professional people have with admitting their fallibility: the threat to ego, to reputation, to vanity. It obliterates progress – not only in healthcare.

We can draw a contrast with aviation, where the culture is very different. In the airline industry, mistakes are seized on as precious learning opportunities. Every aircraft is equipped with two almost indestructible black boxes, one that records conversations in the cockpit and one that records the electronic instructions sent to the on-board computers.

When there are accidents, the boxes are recovered, the data is excavated and the lessons are learned. Professionals



By using this method, aviation has attained a remarkable and still-improving safety record. In the early part of the last century, flying was one of the most dangerous forms of transport. In 1912, eight out of 14 US Army pilots died in crashes: more than half. In 2014, by contrast, there was one accident for every 8.3 million take-offs among the major carriers.

This is not about aviation, however: it is about a method. When the Virginia Mason Hospital & Medical Center in Seattle created an aviation-style system of incident reporting, and altered the culture so that professionals were empowered to speak up, errors plummeted. Insurance-liability premiums dropped by an astonishing 74 per cent. That is the power of learning from mistakes.

What we are really talking about here is scientific method. Science has been



successful precisely because it learns from errors. Scientific theories, by definition, make testable predictions. It is when theories fail that they are reformed or even revolutionised. Just as in aviation, where the safety of the system is paradoxically built upon the rubble of real-world accidents, so the scientific theories of today are built upon the failures of their predecessors.

When we are engaging with a complex world, failure is inevitable. Failure in our assumptions, our theories, our methods and our strategies. The hallmark of great institutions, now and throughout history, has been a capacity to leverage these failures in the dynamic process of change. Institutions founded on authority, on defensiveness, on a lack of courage to engage with mistakes, have held the world back in many ways.

Chesley Sullenberger, the pilot who famously landed US Airways Flight 1549, an Airbus A320, on the Hudson River in 2009, has expressed the basic paradox of success. In a TV interview in 2010, he offered this beautiful gem of wisdom: "Everything we know in aviation, every rule in the rule book, every procedure we have, we know because someone somewhere died... We have purchased at great cost, lessons literally bought with blood that we have to preserve as institutional knowledge and pass on to succeeding generations. We cannot have the moral failure of forgetting these lessons and we have to relearn them."



Matthew Syed is a journalist and the author of Black Box Thinking (John Murray)

MATTHEW SYED

Every situation that works has been built on a mistake

Warfare has changed forever now that there are no secrets

N.



by two V-12 1620 horsepower Rolls-Royce engines, the de Havilland Mosquito was one of the fastest propeller planes in the second world war. But on July 26, 1944, it met its match. A German jet-powered Me-262 entered combat for the first time and attacked a Mosquito on a recce.

The Me-262 was one of the *Wunderwaffen* that ranged from the first jet fighters to V1 and V2 rockets, which Germany hoped would turn around the war. Fortunately, this new generation of "wonder weapons" came too little, too



Peter W Singer is senior fellow at the New America Foundation and co-author of Ghost Fleet: A Novel of the Next World War

late to make a difference against the far greater numbers of Allied weapons, even if those weapons weren't as effective. But finding themselves behind the curve in the technology of war certainly scared the Allies and changed the way that they planned to fight in the future.

For the next 70 years, the US, the UK and Nato led the way. Indeed, the shift from focusing on quantity to quality became their defence strategy. They made sure they had a clear advantage in technology, often a generation or more ahead, so that they could deter would-be enemies such as the Soviets, despite their far smaller militaries, or contemplate invading countries such as Saddam Hussein's Iraq, even though the western strike forces were less than a third of the size of Iraq's.

In the ensuing insurgencies in post-invasion Iraq and Afghanistan this advantage has meant the core challenge has been to find the enemy, not the terms of the fight. As one Marine officer put it to me, if his force of 30 men were attacked by 100 Taliban, he would still be confident his unit would win. Even outnumbered, they'd relish the

opportunity to get a chance to face, and defeat, an elusive foe in a stand-up fight.

Think about the change here. No Allied officer in the first or second world wars could have been so comfortable being outnumbered or even matched.

This advantage of technology, though, is an inheritance that simply may not be there for our militaries in future. The shift to using computer networks has connected us in amazing new ways, but it has also wired in a massive campaign of IP theft. The F-35 Joint Strike Fighter was to be the west's sophisticated new stealth fighter jet, years ahead of any competitors. Instead, the programme has been hacked and China is gearing up its own version, the J-31, for export. The F-35 is far from the only case; the Pentagon's testers found that every major weapons programme had "significant vulnerabilities".

It is hard enough to win an arms race when you are paying for the other side's R&D. But new 21st century competitors are not just copycatting. China, for instance, is spending more on technology R&D than all of the EU, and is on pace to match the US in five years. It is doing world-class work in fields such as supercomputers and hypersonics.

Government once led the way, developing everything from radar to the internet itself and spinning it off to business, but now it's private businesses that are more often ahead. A common complaint of soldiers is not just that their gear is being outstripped by what they can buy at the mall, but that their foes can shop there as well.

Investments in tech that range from next-gen drones to lasers and a new generation of robotics, would be valuable in changing the nature of the game, now that our foes have caught up. But they are not enough. We have to change our expectations and assumptions, and plan accordingly. We think of ourselves as ahead of everyone else, but we cannot be so confident any more. Pride comes before a fall.



More than 400,000 human beings already have a digital device inside their heads, with more than 50,000 new surgical operations taking place every year. Most of these devices are connected to the auditory nerve as cochlear implants, to treat deafness, and a few to the optic nerve or the retina. But a rapidly growing number of people have chips which are directly fused with their own brains.

In many cases, this is to help control involuntary tremors in Parkinson's disease. In other cases, the aim is to give muscle control to paralysed people. For example, Erik Sorto is a tetraplegic who moves his robotic arm by thinking, using an implanted device created by Caltech.

Connecting brains to chips is really easy - once you have got the chip safely embedded inside someone's head. Brain cells instantly recognise digital intelligence, because both chips and brain cells use tiny electrical signals to communicate.

For over 20 years, scientists have been growing biodigital brains, using rat or mouse brain cells and specially prepared neurochips, with roughened areas to enable brain cells to stick in place, coated with special proteins.

Each brain cell grows small branches across the chip surface, searching for life. When a branch picks up an electrical signal from another nerve cell, it forms a connection or synapse. The same happens if it picks up a signal from the surface of the chip. So your brain is genetically programmed to recognise and install such devices automatically, though bio-software may need to be developed.

The first experiments with implanted biodigital devices were



PATRICK DIXON

Would you wear a chip in your brain?

in rats in 1993. And in 2013, Miguel Nicolelis at Duke University, North Carolina, reported that two rats had begun sending virtual messages to each other, brain to brain. He has since created a brain network between four rats, each of which passed sensory data to the other animals, which they used collectively to solve tasks better.

The first biodigital devices in humans were used to deliver visual data directly to the optic cortex of the brain in blind people, bypassing the optic nerve. For over a decade, other implanted devices have allowed paralysed people to control external equipment, or their own limbs.

Command, control and delivery of sensory data are relatively straight-



Patrick Dixon
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the author of
The Future of
Almost Everything
[Profile Books]

forward, but creating digital memory storage for the brain is far harder. Sending an enquiry from brain cells to a biodigital device, and making sense of the answer, is very different from making a simple connection.

There are two health challenges: one immediate and the other very long term. Getting a chip into place means drilling a hole in the skull and cutting through membranes that cover the brain. And after the operation, the chip can irritate the brain, with a risk of epilepsy. Many first-gen devices need permanent wires, which create risks of infection. Tomorrow's devices will be wireless and charged remotely.

But here is the issue with all these innovations. Ask any conference audience whether they would like a biodigital brain implant and they always say the same thing. Interesting, important maybe to help repair damaged people, but it's not something they want for themselves or their kids. Even if you promise extra memory or super-intelligence.

What we learn from this is a fundamental truth about all digital innovation. You may have the smartest device, app, online tool or capability in the world, but adoption depends hugely on how people feel about it. And feelings can change rapidly.

Predicting emotion, mood and deeper human needs is often more important than the innovation itself.



CHRISTIAN JARRETT

We often talk about personality as if it were an ingrained feature of a person, like fingerprints or height. And much as we categorise people as tall or short, we readily apply labels to ourselves and others based on supposedly fixed personalities. Consider the way lifestyle magazines and websites tout the latest quiz to tell you if you're an extrovert or introvert.

But this pigeonholing flies in the face of some empowering facts that challenge the myth of the fixed personality. Your traits do not stay the same through your life, nor even from one situation to the next. And if you want to change your personality, you can.

Let's look first at the influence of different situations. Many of us know instinctively that, in a way, we are not always the same person. Someone watching you with your mother-in-law or boss would likely make strikingly different inferences about your character than someone observing you on a Friday night at a bar with your mates. Mistakenly assuming that aspects of a person's behaviour are permanent is known as the "fundamental attribution error".

The US psychologist Walter Mischel (most famous for the "marshmallow test") conducted seminal work in this area. In one study, he and his colleagues observed the behaviour of children on a summer camp. They found that rather than some children being conscientious and others aggressive, these traits were often situation-specific. For example, one boy might show a hot temper when admonished by adults, but be cool in the face of peer teasing; his friend, vice versa. It would be misleading to label either child as aggressive or laid-back.

One of the reasons our personality traits can vary in different situations is because of the effects of mood on our behaviour and outlook, especially





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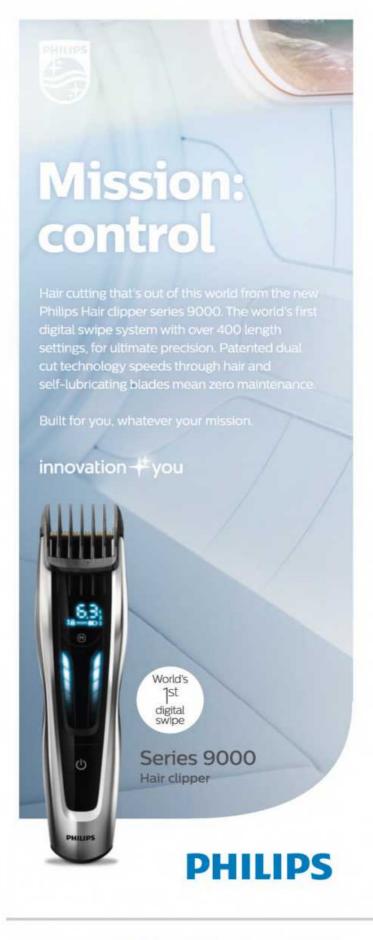
Christian Jarrett
is editor of
the British
Psychological
Society's Research
Digest blog
and contributing
writer at New
York magazine's
Science of Us.
His most recent
book is Great
Myths of the Brain
[Wiley-Blackwell]

sadness. This was demonstrated in a study published last year, when researchers at Bielefeld University played participants a sad video with sad music. This put the participants in a sad frame of mind. When they answered questions about their personality in this state, they scored much higher on neuroticism, and lower on extraversion and agreeableness (associated with friendliness) as compared with when they completed the questionnaire in a neutral mood.

Even if we accept that it's fair to ascribe to someone a personality type based on their averaged behaviour across a range of situations, other research is showing how our traits gradually shift. Generally speaking, as people get older they tend to score more highly in agreeableness and conscientiousness and lower in neuroticism. But these shifts don't happen at the same speed through life. For most traits except agreeableness (which tends to increase gradually) there's a U-shaped pattern, with peak stability achieved in mid-life and change picking up again after.

Perhaps the most exciting development is the idea we can change at will. Earlier this year, psychologists at Illinois had students take two personality tests, 16 weeks apart. They asked how they would like their personalities to change and gave them tips on how to do so (one was to use "if-then plans": if x happens, I will do y). The preliminary finding was that their personalities shifted in the desired directions.

When it comes to personality, even small shifts can have dramatic consequences. Someone behaving more like an extrovert than usual would be likelier to decide to apply for a prestigious job or ring a date – taking their life in new, exciting directions. Of course, these opportunities shape personality, and so the cycle continues.





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Cleo McGee











1/Bvlgari Le Gemme LAZULIA fragrance

This dazzling fragrance is designed to evoke hints of mystical Arabia, with oriental, woody scents combined with jasmine flowers, incense and amber. The word "lazulia" actually translates as "deep blue" in Arabic, hinting this is a perfume to be worn at night. £231 (100ml) Exclusive to Harrods

2/Bowers & Wilkins Nautilus speaker

At 22 years old, the Nautilus speaker looks and sounds as good as ever. The hand-made art piece can be ordered in any colour you like and includes B&W's tube-loaded tweeter. It's the speaker that founder John Bowers dreamed of blending design, technology and excellent sound. £55,000

howers-wilkins.co.uk

3/Russell and **Bromley Poplar** two-eyelet boot

These rich black suede boots bring texture to a smart shoe. Made in Italy, these boots are ontrend – and there's even a matching belt available. Style with a suit to add a twist to a formal outfit, or pair with jeans and a sweater at the weekend, for a more casual but cool look.

russellandbromley.co.uk

4/G-SHOCK MT-G S1000V-1A watch

G-SHOCK's premium range has passed tough environmental tests, but still looks sharp. This MT-G features material innovations including two-layer ion-plating, and the combination of resin and metal allows for greatlooking wear patterns and patina to develop.

www.q-shock.co.uk

WIRED INSIDER'S PICK OF **UPCOMING EVENTS**

WIRED RETAIL

Wired Retail returns for its second year with speakers from a variety of influential companies. Ken Denman from Emotient will explore how facial recognition and sentiment analysis could turbocharge customer service. James Allgrove of Stripe will be discussing a world where the phone is a transactional device, and how this will change customer behaviour. Paired with speakers from Amazon, Uber, Ocado, Zalando, and NOT JUST A LABEL, this event is once again at the forefront of the changes affecting this fast paced and disruptive industry - not to be missed. November 23, 2015 wired.co.uk/retail15

WIRED EVENTS IN 2016

WIRED Health will return on April 29 at The British Museum, followed by WIRED Money in June. In addition to our other annual one-day event, WIRED Retail, we are proud to announce two new dates to add to our roster: WIRED Security and WIRED Energy, bringing our event programme to seven exciting and disruptive summits. Our ever-expanding portfolio illustrates the demand for WIRED's offering of insightful speakers, product exhibitions. excellent networking and more. We will also continue to include Startun Stage pitch rooms for new companies seeking funding and recognition. For enquiries and further information. contact us at wiredevents@ condenast.co.uk



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Excelsior! Stan Lee's heroic tale

A life story in comics – for true believers

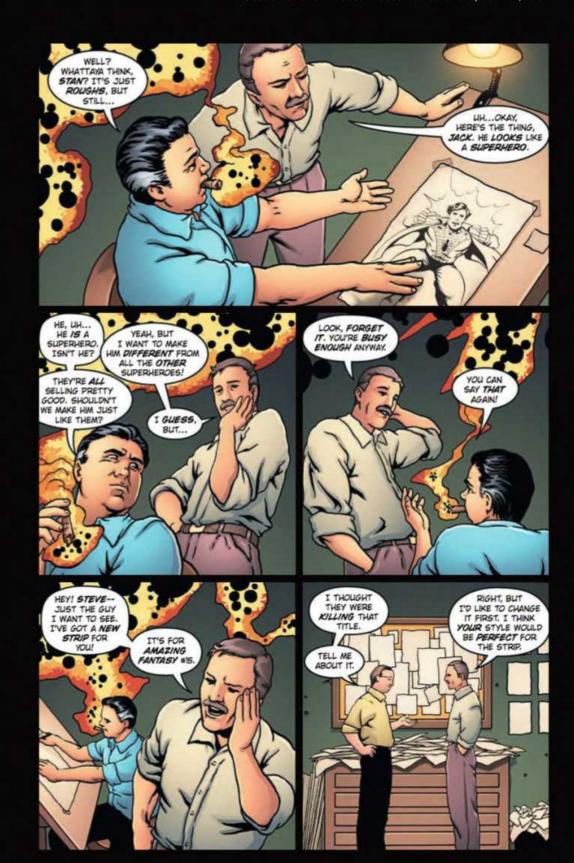
Stanley Martin Lieber –
AKA Stan Lee – has created some of pop culture's most iconic figures, from Spider-Man to The Avengers. But with a carefully cultivated public persona as a loveable huckster, reinforced by his regular movie cameos, the real Stan Lee is rarely seen.

Thankfully, Lee's latest origin story is his own: Amazing Fantastic Incredible turns Lee's life into a comic. Created with writer Peter David and artist Colleen Doran, it's as much a history of Marvel as of Lee.

"I wanted to make it good enough for Stan," says David, who has written for The Incredible Hulk and Spider-Man. "Ideally, this will be read and enjoyed by millions, but I was writing for an audience of one."

Amazing Fantastic
Incredible takes us from
Lee's childhood during the
Great Depression to fanciful
moments such as meeting
Paul McCartney. Lee's
trademark braggadocio
and outlandish enthusiasm
("Excelsior!") are tempered
by a surprising humility.

For Doran, the book was an opportunity to emulate the work ethic of Lee's most famous collaborator, artist Jack Kirby. "I had to break the 'Kirby barrier', which is producing 60 pages or more per month," she says. "It was interesting to force myself to work like the old men of comics, streamlining my storytelling. The art still looks like mine, but it has a classic comics flavour." A fitting way to appreciate Lee, via the very medium he helped revolutionise. Matt Kamen Amazing Fantastic Incredible is published on November 3 by Simon & Schuster











CHARTED

HOW TO MAKE YOUR INSTAGRAM GO VIRAL

#nofilter rules according to social-media analyst Dan Zarrella's study of 1.5m pictures. He found that images receiving the most "likes" on Instagram tended to eschew a filter altogether, while Willow, Valencia and Sierra produced the next most popular snaps, in that order. His other tips? Desaturated, brighter photos featuring faces are a good bet to boost popularity, #and #tag #like #crazv. danzarella.com



Music has the power to entertain and move us; Beatie Wolfe's is also being used to treat dementia. The British singer-songwriter, 27, became interested in music's alternative uses after her grandmother was diagnosed with the disease. Inspired by the late neurologist Oliver Sacks' book Musicophilia, about the effects of music on the brain, Wolfe had an idea. "Every time I would visit. I would perform for her," she says. "The effect was profound: at first she'd be desensitised, not know who I was. After two songs, she'd be back, and able to recall not just me, but much earlier memories. back to her childhood."

The impact inspired Wolfe's Power Of Music project, for which she partnered with 20:20 Research and Spirit of Creation, a design agency. Over four months, Wolfe played in care homes across the UK. "I remember one performance

CARE-HOME CREATIVE

Singer-songwriter Beatie Wolfe is using live music performance to improve memory in dementia patients

of 100 or so patients. Almost everyone was asleep, or in a comatose state, not paying attention; afterwards, they would be talking, humming along. The nurse told me it was the most stimulated he'd seen them." The performances were followed by four months of having patients listen to iPod playlists, curated with the help of their families (20:20 tracked its effect). The results were positive: "Over four months, communication and memory were improved in a lot of patients," she says. Wolfe is developing the project further with her partners, with the aim to raise awareness of the potential benefits.

Next, she is back in the studio recording her second album. No stranger to embracing alternative approaches – her first record, 2013's *8ight*, was distributed as a 3D iPhone app – she is releasing her second, *Montagu Square*, on November 8. It

will include a number of experimental tie-in projects. Among them: a collaboration with the design startup Beatwoven, which translates sound waves into woven patterns, and the tailor David Mason, to produce a song in wearable form. The album, and the Power Of Music project, Wolfe says, share a goal: "To be able to think about music differently". **OF-W** beatiewolfe.com

Wolfe also has spoken about her work at CeBit, DLD, Digital Shoreditch and WIRED events



Co-operate or fail

IN SEPTEMBER, WIRED AND ACCENTURE CO-HOSTED THE THIRD OF FOUR BY-INVITATION DINNER EVENTS. THE EVENING'S DISCUSSION FOCUSED ON COLLABORATION BETWEEN STARTUPS AND INCUMBENTS

PRE-DINNER NETWORKING

THE PRE-DINNER TECH EXHIBITION FEATURED DIGITAL HEALTH PLATFORM UMOTIF, CUSTOM FASHION NETWORK KNYTTAN, CROWDFUNDING PUBLISHER UNBOUND AND OTHERS.



Henry Warren, director of learning and innovation, Pearson, with Hal Watts, founder of Knyttan, ahead of the co-hosted Accenture and WIRED dinner at Vogue House.



Tom Lovett, founder of Sofar Sounds, the online platform changing the way audiences consume live music, with Claire Miller, material designer, Nike Innovation Kitchen.



Tom Kneen, head of business development, British Innovation Gateway, Cisco UK and Ireland, talking to Andrew Humphries, founder of The Bakery.

Nick Hungerford, CEO and co-founder, Nutmeg, with Rajeeb Dey, CEO and Founder, Enternships, and Peter Nixey, CEO & founder, Twistilled Ltd.



t the third Accenture and WIRED co-hosted evening event, attendees discussed how best industry leaders and disruptive newcomers can learn from one another.

"The things that large corporates have are the things that a startup wants and needs, and vice versa," says Samad Masood, Accenture's open innovation lead in the UK and Ireland. "What we try and do is bridge that gap."

Masood joined WIRED editor David Rowan and more than 25 esteemed guests from exciting companies, both established and fast-growing, from the WIRED network. The guests - who debated over dinner and while networking in a WIRED-curated tech exhibition (below, left) - included the likes of Derek White, chief design and digital officer at Barclays, and Henry Warren, director of learning and innovation at Pearson. Also present were Peter Nixey, CEO and founder of content marketing startup Twistilled Ltd, Jess Williamson, director of startup-seeking accelerator Techstars, and Rajeeb Dey, CEO and founder of tech internships site Enternships, among others.

Takeaway points for Masood included "Moving beyond the language of old and new, bad and good, innovative and not innovative, when referring to startups and corporates," he says. "That divisive and combative narrative between large and small companies isn't helping innovation."

He should know. Leading Accenture's UK Open Innovation arm, Masood aims to connect startups with large Accenture clients for mutual benefit.

"With startups, their main asset is that they have a great idea and they have the ability to change that idea quickly," he says. "What they don't have is money, customers, a brand, a network or any exposure to legal and regulatory issues in their area. On the other hand, large corporates have all that stuff – but they don't have the ability to change things really quickly." Visit accenture.com/technologyvision



onder.land is a virtual rabbit hole. The musical, which debuts at London's National Theatre in November, gives Lewis Carroll's psychedelic children's classic a 21st-century makeover, with Alice falling into a labyrinthine web of surreal internet memes.

"Alice in Wonderland is the tale of a girl who goes into a mysterious place where there are no adults from her own world," says director Rufus Norris,

50. "The internet is the rabbit hole that young people escape down now, for all the same reasons."

In the new play, brought to life by Blur frontman Damon Albarn's songs and Moira Buffini's libretto, Alice is a troubled tween who uses her phone to escape into a *Second Life*-like online world where she can engage in heroic feats. For Norris, who took over as the National's artistic director in March 2015, the biggest challenge with

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Alice digital
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with based

fable was that "it doesn't contain anything that resembles a narrative. There are very strong images and episodes and some recurrent themes. But theatre is driven by story." Thus, Wonder.land is only loosely based on Carroll's novel, with many of the book's most iconic characters - Tweedledum and Tweedledee, the Cheshire Cat, the White Rabbit - featured in a cyberpunk guise as denizens of the virtual world.

Some of them will be recreated

reimagining Carroll's tale as a modern

Some of them will be recreated digitally, on vast screens behind the stage, which show much of the action in Alice's virtual dream. Lysander Ashton, creative director of Londonbased studio 59 Productions – the company has worked on some of the West End's biggest shows, as well as the 2012 Olympics' opening ceremony – designed the world and the characters. *Wonder.land*, he says,

Alice and the musical memes

Lewis Carroll's Wonderland becomes a surreal online world – set to music

Above: Rufus Norris, Moira Buffini and Damon Albarn in a rehearsal room at the National Theatre. London

FUMES TURN FABULOUS

is the first theatre piece developed using motion-capture, which 59 used for Alice's on-screen avatar and the ever-grinning Cheshire Cat. "For Alice, we used an entirely suit-based [motion-capture] technology," Ashton says. "We'd just bring the suits to the rehearsal room rather than taking everything out to a specific studio. For the cat, which only appears as a head, we did facial motion capture."

The screens will also be put to use to enhance the actions of flesh-and-blood characters on stage. "There will be real characters who, say, are having a fight, and the screens will provide a digital environment around them, with live video-game-style effects," Ashton explains.

Ashton, 32, reveals that he sifted through more than 1,000 versions of *Alice in Wonderland* – from films to comics and video games – before coming up with his own interpretation

of Carroll's world, which he modelled after the "biological shapes" of amoebas, coral reefs and other microorganisms. Ashton admits that the play's appearance was also influenced by puzzle video games such as *Monument Valley*, whereas in order to flesh out the play's most frightening scenes, he looked at tween-only websites. "I spent many hours on kid's online networks, like Habbo Hotel and Pokemini," he says. "Those I found particularly horrible."

The web, he says, makes a striking parallel for Carroll's surreal fictional world. "We looked at a lot of memes," he says. "You can't think about the Cheshire Cat without thinking about all the cat memes on the internet." **GV** nationaltheatre.org.uk



Tablet extra!

Download the WIRED app for an image gallery from Wonder.land



TRENDING

NOVEMBER POP CULTURE IN ONE SHOT

Strong female leads Exploring ruined buildings

The Hunger Games: Mockingjay – Part 2, November 20

Rise of the Tomb Raider, November 13



Fallout 4, November 10

The colours of the panels respond to the surrounding air quality, ranging from green, meaning excellent, through purple and eventually to red, which is terrible







Last July, a battle broke out. On one side, the cast of TV show Agents of S.H.I.E.L.D.; on the other, those from its sister series Agent Carter. But this was no crossover special. Instead, they were competing over Twitter to see who could make the best video using Dubsmash, an app for recording yourself lip-syncing to audio clips - song snippets, say, or lines from films. (Team Agent Carter won, with a three-person musical effort that included a cameo from Captain America's Chris Evans.) This may be its most

> high-profile public case, but Dubsmash enthusiasm isn't limited to Marvel signings. So far, the app has been downloaded more than 75 million times in more than 190 countries.

> While lip-sync selfies might seem frivolous in concept, to co-founder Roland Grenke Dubsmash fills a glaring gap in the market. "We thought, 'Video is underused as a medium, so why aren't there nice apps out there so that the average user can create interesting and appealing video content?" says the 27-year-old Berliner. Dubsmash is free to use and makes money through promotional Dubs, such as the recent campaign for Rihanna's "Bitch Better Have My Money".

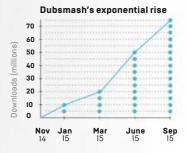
> The app's success did not come without casualties. Since founding their startup Mobile Motion in 2013, Grenke and his partners Jonas Drüppel and Daniel Taschik

released two video apps - Clipsandwich and Starlize - that sank without trace. Their epiphany came in extending the range of sounds beyond song snippets, and realising that messaging was just as important as public posts.

Since Dubsmash's launch in November 2014, hundreds of thousands of videos have been created and shared by users including Arnold Schwarzenegger and Cara Delevingne. But Grenke is aware it could have proved a flash in the pan. "To avoid that, it was important to make *Dubsmash* a means of expression rather than simply a game," he says. "For instance, in Facebook conversations, instead of saying, 'I'll be back in ten minutes,' they're doing The Terminator's, 'I'll be back'." (On any copyright issues, Grenke is confident: "If studios really don't want to have their content on the platform, they can request to have it taken down.")

In August, the company secured Series A funding led by Index Ventures worth \$5.5 million (£3.5m). The money will partly go towards making Dubsmash a place for dissemination rather than merely creation. So what's Grenke's tip for lip-sync success? "The more you don't expect the sound being on the video, the bigger the impact," he says. "So if I'm doing a dolphin noise, for instance, it has a great effect." Charlie Burton dubsmash.com

Pictured, top-bottom: Dubsmash co-founders Jonas Drüppel, Daniel Taschik and Roland Grenke



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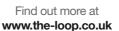
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Inside Ford's supercar skunkworks

How does a £94bn-revenue global corporation innovate? Through a breakout startup with one mission: go faster At Ford Performance, near the auto giant's Dearborn, Michigan, HQ, Dave Pericak has a sign in his office that reads, "Cowboy Country".

Ford has a staff of around 187,000 and had revenues of \$144 billion (£94bn) in 2015. How does such a massive entity innovate? Answer: a small team that operates outside the company. Ford Performance is a group of 130 people founded in March 2015 on the merger of its US-based Special Vehicle Team and its European Team RS (Rallye Sport). Its creations include the Mustang Shelby GT350 and the Focus RS, a 350bhp, four-wheel-drive hatchback in development.

"We are a skunkworks," says Pericak, director of Ford Performance. "I'd equate our role to that of the Navy Seals. We're recognised as specialised, we have to move fast and break the rules."

Eighteen months ago, Ford began a top-secret project to develop one of the world's most advanced supercars: the new Ford GT. A decade on from the last iteration, the 2016 GT will have a top speed in excess of 320kph, taking on Ferrari, McLaren and Lamborghini – plus electric supercar marques such as Rimac and Renovo.

"Only about 50 people knew about it before it was unveiled at the Detroit Auto Showin January," says Moray Callum, Ford's vice president of design. "We used to meet at strange times of day so as not to arouse suspicion." Smartphones were banned. Most areas of the Ford facility are accessed via an electronic card; the underground home of the GT project, previously a storeroom, was accessed by >





an old-fashioned key held by no more than a dozen people.

Only 250 GTs will be built each year, fewer than 1,000 in total, and are expected to cost around £250,000. It has been created to facilitate Ford's return to Le Mans, the world's oldest endurance race, and to trial technologies that will filter down to mainstream models.

For a vehicle built in such small numbers, the GT's complexity is staggering. Fifty sensors – monitoring functions from pedal positions to humidity – produce more than 100GB of data per hour, which is analysed by 25 microprocessors, instructed by more

than ten million lines of code and processing 300MB of data every second. Even the door lock has its own code and microprocessor. (For context, Boeing says its Dreamliner aeroplane uses 6 million lines of code.)

But the main innovation is its use of materials. Most of the vehicle is carbon fibre: the wheel rims, for example, are 40 per cent lighter than the aluminium equivalent. Reducing the mass makes the suspension more effective, boosts fuel efficiency and improves the power-to-weight ratio.

Much of the early design took place in a virtualreality cave in Ford's R&D facility in Dearborn. "The GT was spatially calibrated to the room," explains VR technician Elizabeth Baron. "This allowed the designers to explore the car without having to build a physical model." By using a headset, a carefully positioned seat and a pointing stick, researchers

are able to walk around the car, sit inside or even fly through the bodywork. This means they can optimise components before physical prototypes are built.

The designers can see how the shape interacts with the "real" world, by viewing it against different backdrops

2. CRAFT CLASS An early rendering of the exterior of the Ford GT, executed in clay, in the design showrooms in Dearborn, Michigan

3. TOP MODELS Three of the prototypes made from Styrofoam still sit in the studio, showing the GT's design progression



3





4. DIGITAL
DESIGN
A sketched
impression
showing the
GT's cockpit

sitting next to a mainstream guy who's not allowed to break the rules."

The team also had access to cutting-edge tools. The GT will be the first Ford to be developed using a driving simulator, commonplace in Formula One but relatively new to the road car. Given that hand-built prototypes cost millions of dollars, that helps to make such low-volume projects viable. Another development tool was more old-school: the team built full-size models in Styrofoam.

Although most Ford Performance models, such as the Fiesta ST or Focus RS, are built on mainstream production lines, the GT will be assembled by an outside supplier. Multimatic Motorsports is based in Ontario, Canada; it will also build the racing versions. The cars will be largely hand-built, avoiding the huge tooling costs of mass-production.

Its biggest test comes in 2016, when the race version will launch a fresh assault on Le Mans, 50 years after the original GT40 made history. After all, designing a supercar boils down to just one thing: going faster. **Alistair Weaver** ford.co.uk

from cityscapes to B-roads. Early aerodynamic testing was also carried out digitally using computational fluid dynamics (CFD), which uses computer modelling to assess how the shape interacts with the air. Results were then verified in a wind tunnel using a scale model.

Small performance-driven subdivisions are nothing new. BMW has M Power, Audi has Quattro and Mercedes has AMG – but they're normally high-margin offshoots of luxury brands, rather than

mainstream monoliths. Incorporating such an agile operation into a company whose biggest selling model is an F150 pick-up truck, is not without its difficulties.

Autonomy and privileged access can create tensions in such a huge, bureaucratic organisation, hence the separate facility. "For strategic reasons we're not on the main campus," Pericaksays, "and everything is under one roof. This is a key enabler for us. It's hard to have one of our guys



Digital extra!

Download the WIRED app to explore the Ford GT in full

CAST YOUR NET WIDER

Murder-mystery podcast Serial returns soon for a second season. But while you're waiting, WIRED presents three of our favourite non-fiction podcasts.



Criminal

Can an animal be a convict? This is just one of the subjects covered by Phoebe Judge, Eric Mennel and Lauren Spohrer as they explore the underworld with surprising subtlety. thisiscriminal.com



The Atavist

From unravelling an extortion plot to a scheme to feed America hippos, *The Atavist Magazine's* podcast, narrated by founder Evan Ratliff, serialises its best non-fiction novellas. *atavist.com*



Mystery Show

Each week Starlee
Kine deciphers weird
and wonderful tales:
how a video-rental
shop disappeared
overnight, and the
story of Britney Spears
and the obscure book.
gimletmedia.com
Cara McGoogan



Turn your smartphone into a hero



Our screens are intended

to replace paper and card – but not for Etienne Mineur. The French designer's startup Volumique is reuniting digital and physical through board games. By blending origami art with smartphones, Mineur's titles use everyday tech to augment tabletop fun. "The idea came to me when I

saw one of my children playing with my phone as if it were a plane," says Mineur, 47. He created a *Battleships*-like game as proof-of-concept: the phone was a boat, with animation and sound triggered by its accelerometer.

Volumique now develops a number of titles, including games for Hasbro. Its new game Dungeon Mini, out this month, uses touch-enabled figurines which players move around a virtual castle, exploring and fighting in real time. But Dungeons & Dragons fans needn't worry: "The goal isn't to replace board games," he says. "It's for everyone to share a great time around a table." **OF-W**



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An artist who goes with the flow

MAGNETIC FIELDS PROVIDE THE PERFECT CANVAS FOR LINDEN GLEDHILL'S FERROFLUID CREATIONS

Linden Gledhill
uses high-speed
photography,
microscopes and
magnets to
capture the quirks
of ferrofluid. An
oily suspension
of magnetic
nanoparticles, the
liquid's response
to magnetism
is, well, highly

attractive. "It's unique in the way it behaves," says the Staffordshireborn artist, who is now based in Philadelphia. "If you adjust the magnetic field, the ridges change dimension – and combining field strengths



creates pretty amazing shapes."

A trained biochemist, Gledhill has been experimenting with ferrofluid for years – in the image here, 360-degree coloured lighting turns the normally dark liquid into

abstract art.
"The surface is incredibly smooth, so although it's black to the naked eye, it will reflect light like a mirror," says Gledhill, 52. And by using focus-stacking techniques – whereby 20

layered on top of each other – he brings clarity to the most microscopically intricate details.

"There's a lot more that can be done with ferrofluid," says Gledhill. "When it dries, it changes its character and becomes highly coloured, so I've been doing more unusual things with it in terms of the microscopy."

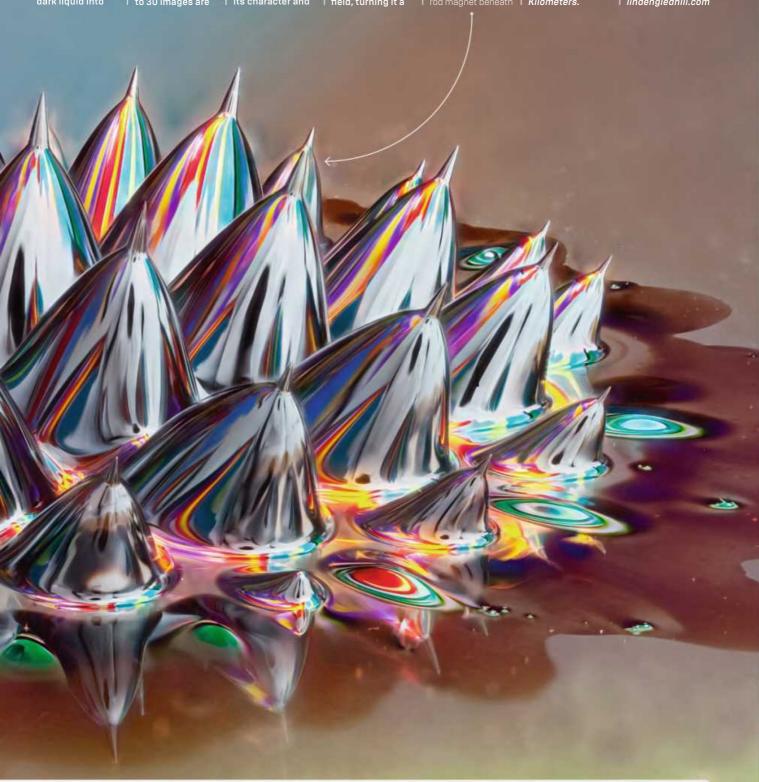
In some of his other pieces, Gledhill has artificially dried the ferrofluid in the magnetic field, turning it a rusty orange. "It's a different way to represent it," he says. "Others who have worked with it haven't tried affecting the chemistry in

The ferrofluid here is 1.5cm across, on a glass plate, with a rod magnet beneath

this way." And there are further experiments, such as developing a ferrofluid-based font with the typographer Craig Ward, and creating special effects for Mike Pecci's indie horror film Twelve Kilometers.

"The ferrofluid didn't really work as a movie monster – we'd intended for it to be much scarier," he says. "But I did get to move it magnetically through brains and over skin."

Sophia Epstein lindengledhill.com



With more than 63 million Facebook

fans and a billion-plus YouTube plays, Linkin Park are, according to their social media and YouTube activity, the biggest rock band in the world. But when they're not playing sell-out stadium tours, they have a new project: helping startups become rock stars, too. In January, the band launched Machine Shop Ventures, which is designed to invest the band's money – and their expertise – in technology companies.

Musicians investing in tech is nothing new: in the past few years, artists-turned-investors range from Jay Z to Bono and even Justin Bieber. Some of their funds are successful, others (much) less so. What makes Linkin Park unusual is the companies they're backing: hot, high-growth companies such as ride-sharing app Lyft, logistics startup Shyp and Blue Bottle Coffee. Early investments also include stakes in Robinhood, a stock-trading app; storage startup PlugAir; software company OpenLabs; and Turnstile, a live events startup. Even more unusual: it's the band members themselves behind it.

"The impetus was that we want to build relationships with really smart people who are doing innovative and disruptive things, because it helps us grow," says guitarist Brad Delson, 37 (*main image, centre*). "We didn't want to say, 'Hey, let's give money to one of these fund managers."

That do-it-ourselves instinct goes back to 1999, when Linkin Park itself was a startup of sorts. "I remember packing up boxes of cassettes and stickers in Rob's apartment and sending them off to fans," says Mike

Park's How the members of the world's biggest band found a way to help small startups go global Theory

Shinoda (*main image, left*), the band's 38-year-old co-vocalist and instrumentalist. "It was street-team marketing." When the band's debut album, *Hybrid Theory*, sold 27 million copies, other artists asked what the secret to their success was. "They were looking to us, saying, 'How did you do it?"

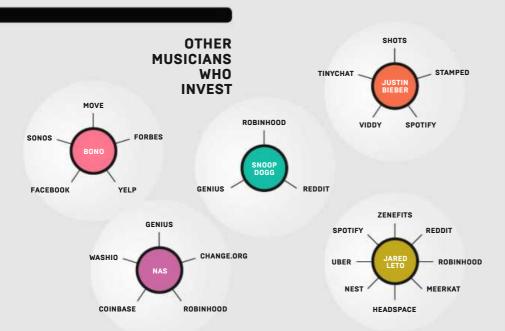
Traditional artists might withhold their secret sauce; instead, Shinoda and his bandmates set up their own marketing company to help other new acts do the same. Now known as Machine Shop, the creative studio houses everything from production to management to Underground, the band's fan club. "Our *modus operandi* has always been to try and interact directly with our fans, and to have control over everything we're working on creatively," says Delson, in Machine Shop's HQ in downtown LA. "We don't want middlemen." Through Machine Shop, the band has built a reputation for being prolifically creative, whether through solo projects or collaborations with other artists

and companies such as the messaging app *Line* and the fashion label BAPE.

Some of the band already had experience in startups: Shinoda has personally invested in Sonos and Spotify, and had been involved with two funds managed by Lowercase Capital. They also spent time with investors at Y Combinator, the respected Silicon Valley incubator, and meeting VCs and founders. When any company is considered, the bandmates test the product and meet its creators. The priority, Shinoda says, isn't returns: it's about finding companies that the band can partner with and vice versa. Lyft's ride-sharing, for example, ties into the band's environmental concerns (their charity, Music For Relief, raised money to fight climate change), "and it's a sober driving solution for people coming home from Linkin Park concerts," says Shinoda.

It's not all one way, either: the band provides advice to growing companies (Shinoda consulted on the user-experience for OpenLabs' music software StageLight). "If you're a company looking to build a worldwide community, the band has phenomenal

Right: Mike Shinoda and Brad Delson, members of Linkin Park, and Kiel Berry, vice president of their creative investment fund Machine Shop Ventures





experience in that," says Kiel Berry, vice president of Machine Shop Ventures. "If we're talking to a company about China, we know people in China."

According to Berry, Machine Shopboth its venture arm and creative studio – reflect a wider trend: with musicians reliant on technology for distribution and reaching fans, the creatives' personal involvement is inevitable. "We're seeing tech and entertainment starting to merge," he says. He points to the band's use of drones (used to film live concerts), virtual reality and even gaming.

"The guys are engaged in technology in ways that would surprise you. They're like Tony Stark with a guitar."

That won't stop the haters, of course: when Machine Shop first launched, some in the startup and music industries questioned their motives. But in the end, Shinoda says, that doesn't even matter. "Linkin Park and our music is the core. Everything else is built around it."

Delson gestures to the room. "Ultimately, if what's going on here isn't serving the music, it wouldn't exist." **OF-W** *machineshop.co*

DRONE RACING: It's a sport



On an abandoned
farm on the outskirts
of Brighton, the UK's
top drone racers are
duking it out – but they're
not looking up at the sky.
This is the fast-growing
sport of first-person
view (FPV) racing, which
combines nimble
quadcopters, cameras and

"It's a mix between flying a plane and a Star Wars podracer," says Dan Waring, 19, the reigning UK drone freestyle champion. Waring flies a modified Emax Nighthawk with Fatshark Attitude V2 video goggles, and specialises in performing freestyle tricks that send his drone spinning through the sky in a series of improbable twists and falls. "Getting this new perspective allows for pilots to race in the front seat," he says.

video goggles to give pilots a drone's-eye view.

The sport is already big news in the US, where the recent National Drone Racing Championships, held alongside California's State Fair, attracted 120 pilots and garnered thousands of YouTube views. The rise in drone popularity has also encouraged the creation of other sports, such as Robot Wars-like combat fighting, made popular by the web series Game of Drones.

FPV's biggest draw,
Waring says, is that the
nascent technology allows
for broad access. "Anyone
can get involved in FPV
racing," he says. Looks like
drone sports are about to
take off. James Temperton





Berlin-based artist and coder Andreas Nicolas Fischer has created Schwarm, software that uses a picture's colours and shapes to assemble sequences of abstract images. His work is available on online art platform DAD. anf.nu

▼RELATIVE SUCCESS

After making a splash with their underwater video for "River", French-Cuban sisters lbeyi are preparing for their biggest UK tour yet, kicking off in Brighton on November 2 and winding up in Glasgow a week later. ibeyi.fr

► DEVELOPING NEWS

Polaroid Snap is a digital camera that can print your pictures in less than a minute. Its Zink (zero ink) technology allows it to churn out photos using a chemical reaction rather than ink cartridges. Take that, Instagram. polaroid.com

118 / PLAY / CULTURAL PICKS OF THE MON

■MILAN'S NEWCULTURAL MECCA

Milan's Museo delle Culture is the Italian city's must-see new building. The museum, redesigned – and then disowned – by David Chipperfield, combines crystal-and-zinc walls with a floral shape to maximise light. mudec.itw

▼ALMOST THERE...

Episode VII isn't out until December, but EA DICE's Star Wars: Battlefront shooter will make your wait more than tolerable. This is the game you are looking for. Available on PS4, Xbox and PC from Nov 20. starwars.ea.com

▼ SCOUTS' HORROR

Paranormal Activity 2 writer Christopher Landon is back with Scouts Guide to the Zombie Apocalypse, in which khakishorts-wearing dudes face brain-craving ghouls. Includes SFX by Alterian, the team behind Daft Punk's helmets. Out Nov 6



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07.15 INSIDE GOOGLE'S SECRET ARTIFICIAL INTELLIGENCE PROJECT



04.15 WIRED HACKS NORTH KOREA



01.15 STEPHEN HAWKING – EVERYTHING IN THE UNIVERSE EXPLAINED



09.15 THE 2015 WIRED 100 ISSUE: THE BIGGEST HITTERS IN THE WIRED WORLD



06.15 ÜBER – 41 LESSONS FROM A \$40BN PHENOMENON



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12.14 BUCKLE UP! THE WORLD'S FIRST I,000MPH CAR



08.15 PRODUCT SPECIAL: EVERYTHING YOU NEED TO LIVE THE WIRED LIFE



05.15 HOW DATA SAVED MUSIC - INSIDE KOBALT



02.15 NETFLIX - HOW REED HASTINGS BEAT AMAZON & YOUTUBE



11.14 THE DATA INDUSTRY IS SELLING YOUR LIFE



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Stars & clouds

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network capacity of the
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and thousands of smaller
organisations – with its
secure, fast and reliable
ICT infrastructure

Lee Myall, Interoute's senior vice president of computing (*left*), with ESA's CIO Filippo Angelucci The European Space Agency (ESA) produces a lot of data. Ensuring all the information captured from its Earth observation, manned space flight, lunar study and space exploration is accessible across ESA's seven major European sites is the job of its CIO, Filippo Angelucci.

"ESA is organised into a number of directorates, each with a specific scope – like launchers, science, telecommunications, technology, Earth observation," he says. "We are the part that ties them together with information systems."

In addition to providing critical IT services, Angelucci's team enables each of ESA's major projects, such as the control of satellites in space.

That's a big job. To efficiently deal with the task, ESA partners with third-party providers to assist with services such as network provision and cloud computing. Interoute is one such partner.

"The services that we need to deliver to ESA are so high that we have dedicated staff on site," says Lee Myall, senior vice president of computing. "Earth observation takes in huge amounts of data, and they have an elastic way of using our services."

This is done on Interoute's Unified ICT Platform. In addition, ESA utilises Interoute's virtual data centre (VDC). The VDC is built on Interoute's global fibre-optic network and gives organisations – as big as ESA or as small as a startup – the same control and resource as having their own data centre, but without the cost, power, co-location, network and manpower requirements.

"ESA has these massively diverse requirements, from corporate IT to huge heavy lifting. And they can be happy with us as a supplier for all that," says Myall.





PSYCHOLOGY

Nudge, nudge. Think, think

Governments are deploying behavioural insights to shape our actions. Do you want to give them that power? By David Halpern and Owain Service

IF YOU'VE RECENTLY RENEWED

your car tax, chances are you were nudged. As you finished, a "thank you" page asked if you'd like to join the Organ Donor Register. It's the most basic form of nudge. You were simply asked, and could click "join" if you felt like it. This prompt, placed on gov.uk in early 2013, has led to hundreds of thousands more people joining the register each year.

Eight variations of the message were tested. One simply said: "Every day thousands of people who see this page decide to register", beside a picture of a group of happy, healthy people. It was based on the principle of social norms – people are influenced by what others do. Another, based on reciprocity, said, "If you needed an organ transplant, would you have one? If so please help others."

One of the above led to a jump of around 40 per cent in those joining from the page; the other led to a slight drop, relative to no message at all. The other six boosted joining by 20 to 35 per cent. But can you guess which led to the 40 per cent rise? Are you sure? Sure enough to recommend a policy based on your hunch? It was the message with the picture that caused the numbers to drop; the most effective was the one encouraging people to reciprocate, and the gap between the two was equivalent to 100,000 people joining per year.

This was one of many trials that have been conducted over the last five years by the 10 Downing Street Behavioural



Fig. 1 Steering people without their informed consent carries ethical risk

Insights Team (BIT) – or "Nudge Unit" – set up by David Cameron in 2010. Such trials brought two insights into the heart of government. First, how seemingly small changes in processes or wording have big impacts on real people, unlike the "econs" of textbooks. Second, the importance of trialling. Even with the best expertise in the world, you can't be sure how exactly humans will react. From this new viewpoint, the traditional approach to policy looks very strange: why would passing a law, or spending billions on a tax subsidy, lead to the behaviour that the policymaker expects?

The team was staffed by psychologists, economists and civil servants familiar with government - and ideally people with a background in all three. It had a sunset clause: if it failed to achieve a ten-fold return on its cost, and affect at least two major policy areas, it would be shut down on its second anniversary. The experiment worked1. It showed that small changes to the wording of letters, such as "Nine out of ten people pay their tax on time", brought forth millions in tax paid; and that carefully worded texts more than doubled the number of jobseekers turning up for a job interview. Dropouts from further education could be cut by a third and the number of debtors paying a court fine without bailiffs could be boosted three times over.

Other interventions were more elaborate. Jobseekers got back to work faster if advisers asked how they would be using their time in the coming week rather than what they did last week –

the approach that had been used for 30 years. The team used behavioural insights to boost take-up of business support schemes; reduce fraud and error; increase savings; reduce clinical mistakes; reduce missed appointments; and increase recruitment levels and performance among minority groups. The team also advised on policy issues such as how to speed up loans to small businesses and ensuring that e-cigarettes are more widely available.

In the wake of these results, the Prime Minister decided to expand the team. Demand grew, not just from the UK public sector but internationally. In 2013, the Behavioural Insights Team was turned into a social-purpose company, co-owned by the Cabinet Office, the innovation charity Nesta and the employees. It now helps governments across the world who face an ever-increasing range of challenges, including obesity, social mobility, productivity and even extremism.

Nevertheless, the growing use of behavioural science and active experimentation by governments and businesses raises wider questions. After all, who nudges the nudgers?² In the US, where the idea of nudging was popularised by Cass Sunstein and Richard Thaler, the argument runs that nudges should be "choice enhancing", or at least not-reducing. For example, changing the default on workplace pensions from an opt-in to an opt-out has led to millions more savers – more than five million in the UK alone since

If governments and businesses want to experiment, they'd better bring the public with them

2012 - but still keeps the choice of opting out. However, many of the choices we make every day, and that are susceptible to nudging, operate on a relatively unconscious level. Using larger plates in a restaurant buffet leads people to eat more (and produces more food waste), and diners are unaware of the effect. But how do we all feel about governments, or businesses, deciding how big the plates should be? The greater use of nudging brings with it a need to strengthen the ways through which citizens can nudge the nudgers, such as through the use of deliberative juries whereby members of the public give a direct steer as to what is, or is not, deemed an acceptable nudge.

Following the Nudge Unit's success, similar units are being set up in Australia, Germany, and Singapore. Even the White House created a Social and Behavioural Sciences Team, and in September published its early results. These showed, just as in the UK, that small changes in wording and processes could boost the number of veterans taking up benefits, help disadvantaged students, and increase revenue declared and received by government commissioners. Governments are scaling up these approaches, applying them to seemingly intractable problems.

Many citizens and entrepreneurs are using the techniques too. Behavioural interventions have proved capable of boosting social and economic outcomes, and are cheap and non-intrusive. But they also involve decisions that shouldn't be left to behavioural scientists alone. We all have a role in nudging the nudgers. David Halpern is chief executive and Owain Service is managing director of the Behavioural Insights Team.

ETHICAL ISSUE OF THE MONTH-

SHOULD WE TWEAK THE HUMAN GENOME?

In April, a lethal gene associated with an inherited blood disorder was removed from human DNA. Experiments, performed in non-

from human DNA.
Experiments,
performed in nonviable human

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embryos, showed that in theory the technique human-genome editing - could precisely replace faulty genes. It involves a molecule called CRISPR engineered to locate a problem in the genome. A protein called Cas9 works with CRISPR to cut out the unwanted part. Synthesised

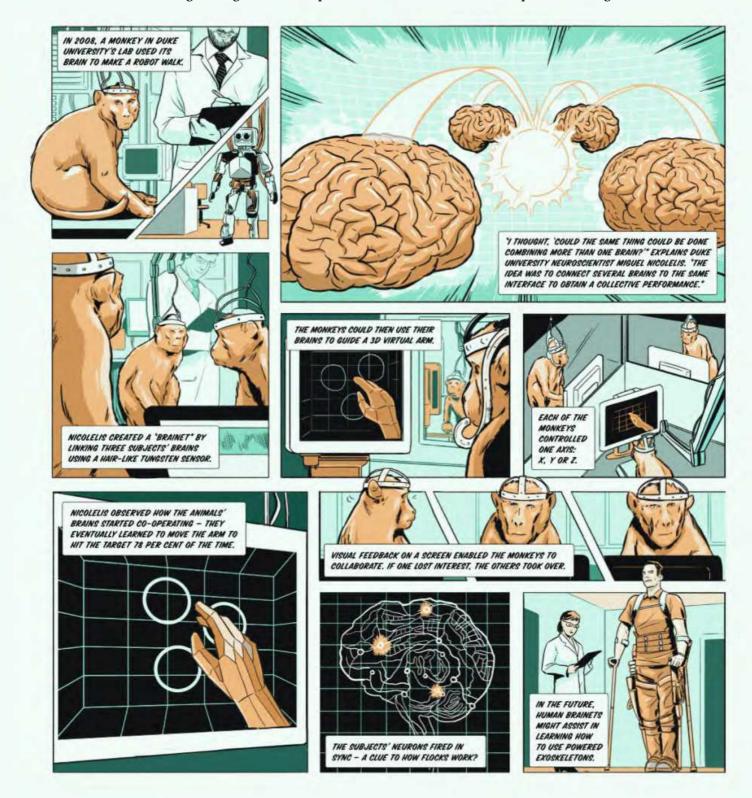
DNA, placed in the cell with CRISPR/ Cas9, substitutes the faulty gene. Scientists worry that it could trigger eugenics. Yet "there are gremlins in the DNA that vou'd want to remove," says Tony Perry, a biologist at the University of Bath, "This offers us the opportunity to sidestep them."

Emma Bryce

1. Even the Daily Mail was impressed:
"How a packet of sweets can help TREBLE
the number of bankers who will give money
to charity," it wrote on July 23, 2015.
2. Experimenting with the public brings real
anxiety. Governments need to avoid the recent
mishaps of tech giants, burned by public
reactions to their unseen experiments.

BUILDING A BRAINET

Each month we illustrate a hot lab study. This issue: how Miguel Nicolelis, a neuroscientist at Duke University, researched brain-computer interfaces – controlling devices using brain signals sent via implanted electrodes – to understand co-operative thinking



David Eagleman is exploring how we're wired

NEUROSCIENTIST AND AUTHOR David Eagleman, at the Baylor College of Medicine in Houston, Texas, studies the way our brains perceive our environment and construct our individual realities. He explores time perception, synaesthesia and the neural mechanics behind the sensory experience – all topics in his book, *The Brain* (published in November alongside a US PBS TV series). Eagleman attempts to define the brain, explaining how it takes shape and how we could retrofit it to enhance our sensory appreciation.

One such retrofit is the Versatile Extra-Sensory Transducer (VEST). A tank top packed with microcontrollers and vibating elements being developed in Eagleman's lab, the VEST aims to give a form of hearing to those who are hearing-impaired. It's driven by the principle of sensory substitution, a major area of Eagleman's research that looks at how technology could tap different sensory pathways to allow someone, in effect, to regain a lost sense. Worn

on the torso, the garment converts sounds into vibrations that play on the wearer's skin, relying on the brain's ability to extract information from a multitude of sensory signals, regardless of origin. The brain learns to interpret individual VEST vibrations as particular sounds, allowing people without hearing to navigate complex soundscapes.

WIRED speaks to Eagleman about his invention, his book and how the brain's structure makes it possible to enhance our sensory experience of the world. Emma Bryce

WIRED: In *The Brain*¹ you say that from birth, human brains can "wire on the fly". What does this mean? David Eagleman: Yes, the remarkable thing about the human brain is that

it is extremely plastic, meaning it

tasks at hand; it comes to reflect the environment that it drops into. Every time you learn a new fact, for instance when you learn that my name is David, there is a physical change in your brain. It's especially true when we're young and we learn about the culture that we're in, and we absorb the language that happens to surround us. But throughout our lives this continues.

adjusts its own circuitry to match the

Your book describes a famous brain – Einstein's – that "rewired", revealing the brain's plasticity in adulthood.

When Einstein donated his brain to science [after his death] everybody thought, "Now we're going to see what a genius brain looks like." But the main thing they found just reflected that he played violin: there's an area on the motor cortex that corresponds to finger movements on the left hand, and a violinist uses their left hand for very detailed, fast motions.

In some of your work you exploit this characteristic to give humans an enhanced perception of the world. What drives this idea?

I'm working on the ways we can expand the sensory signals that we take in², so that we're not just stuck with eyes and ears, noses and fingertips that only pick up a very narrow slice of signals out there. There's no reason why we can't expand that massively. This is related to the issue of brain plasticity: the way I view the brain is as a general-purpose computational device, and it doesn't care what kind of sensors you plug into it, it just figures out how to use them.



PSYCHOLOGY -

Sex doesn't sell, and the advertising industry knows it

A study debunks all the things you think you know about ads

The image:
A woman bends
over a stove,
wearing lingerie
and oven gloves
under the
headline: Can
She Make You
Lose Control?
The product:
antiperspirant.
It's a Lynx ad,
and of course,
sex sells.

It would seem everyone, except for advertising professionals, can see sex doesn't sell. I studied at Boston University for a bachelor of science in advertising and communication, and we were told: "Sex only sells if you're selling sex."

But when it comes to selling anything else, from washing powder to ale, the research has always shown that, at best, sex does nothing. This is reflected in a study just published by the American Psychological Association

from Ohio State
University
researchers
Robert Lull and
Brad Bushman.
It is a metaanalysis of 53
past experiments
involving a total of
8,489 subjects. In
those studies, the
researchers ask
people if they'd
be interested in

purchasing a product after viewing an ad. (They don't follow them for several months to see if they would cave in and buy the brand of cat litter with the shirtless man on the box. There's a chance you would, even if you said you didn't like

You're developing the wearable VEST and with it you're exploiting the sense of touch. Why touch?

We're taking advantage of skin, this incredible computational material, and using it to pass on data. We pick up sounds and do all the computation to break it into 40 streams of information. The VEST has vibratory motors all over it and we convert the data into patterns of vibration, which we tap as a dynamic moving pattern on to the torso.

How does the brain learn to interpret these strange vibrations as sounds?

Each motor represents some frequency band: low, high and everything in between. If I'm talking to you, my voice is represented by a sweeping pattern of touch across your skin. By establishing correlations with the outside world - as in, every time I hit this piano key I feel this pattern, or every time someone says my name it feels like that - the brain eventually figures out how to translate the patterns into an understanding of the auditory world. Whether that feels exactly the same as hearing is unknown, but it amounts to the same thing. Just think of the way a blind person passes fingers over Braille: the experience may not be exactly like seeing words, but the way the meaning flows off the page is equivalent. It sounds like it would be a real challenge, but that's what brains are really good at doing: unlocking patterns.

When will the VEST be a reality?

We've got prototypes and we're testing it now; we're probably ten months from having a consumer-ready version.

- 1. Eagleman's previous best-selling book was Incognito: The Secret Lives of The Brain.
- 2. Eagleman's lab wants volunteers with synaesthesia or hyperthymesia. (Check if you experience these at synesthete.org and mylifememory.info.) Email perception@ cns.bcm.edu - testees are compensated.

BIOCHEMISTRY

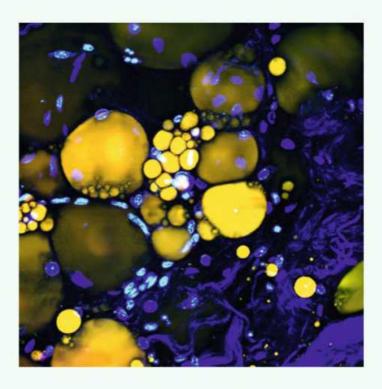


IMAGE OF THE MONTH

Dyeing single cells targets them with laser-like accuracy

THESE LASERS ARE HUMAN CELLS. SEOK HYUN YUN AND MATJAŽ Humar, optical physicists working at Harvard Medical School, have injected skin and blood cells with droplets of oil and fluorescent pigments, or ten-micron polystyrene beads. As a result, when the dyed cells are stimulated with a light pulse, they are able to emit a beam of tightly focused light, which is similar to that of a laser. As every laser can be given a different "signature", the invention could one day be used to tag individual cells, and possibly even to track the development of tumours over time. That in turn could potentially lead to creating highly targeted therapeutic regimes to treat very specific areas.



it, but that chance is very small.)

The evidence is compelling: the study found that neither sexual nor violent ads helped improve effectiveness, and even ads placed within violent media had a negative outcome, all of which should

make the *Game* of *Thrones* producers happy that it's only on premium cable and satellite networks.

If you must advertise a product with violence, possibly because you're selling ninja throwing stars or bazookas, the study showed that it would be least useless to place it within a similarly violent context.

If all of these studies say sex doesn't sell, and ad professionals know it, why do so many ads still use sex to sell? Surely they wouldn't bother if they knew it didn't work? Well, judging by my years spent in the business as a lowly copywriter, the answer to that is simpler than you might realise: ad professionals don't decide what to put in the ads; the client does.

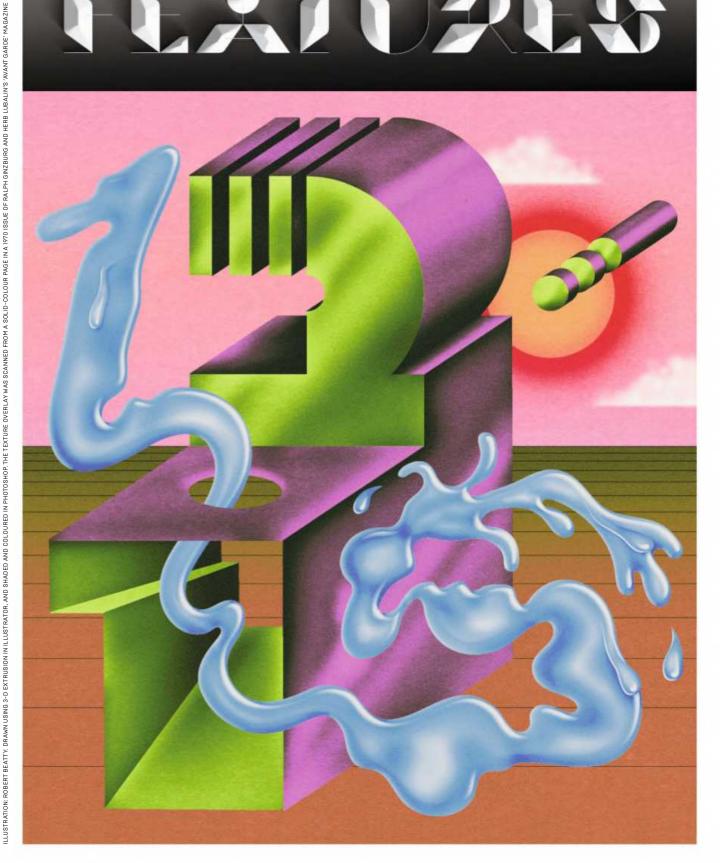
wants a shirtless man on that catlitter box, then that's probably what will happen. And I would buy it, science be damned. Rebecca Watson runs skepchick. org, a network of science and critical thinking blogs

WIRED

JJ ABRAMS TAKES WIRED TO A GALAXY FAR, FAR AWAY...

JANUARY/FEBRUARY DOUBLE ISSUE. OUT DECEMBER 10





"No one has individual ownership of an idea." John Lasseter, pl32

How do you build a successful growth company when the old rules no longer apply? For this special business edition, WIRED goes inside three very different corporate cultures: an entertainment hit factory, a manufacturing giant and a gaming phenomenon. To introduce the section, guest writer SAUL KLEIN examines how bold thinking can transform both upstarts and incumbents

The long-haul business plan





The main reason those who run legacy businesses are worried and confused is that we have, seemingly overnight, found ourselves living in a transformed world, where – thanks to the irresistible rise of the smartphone – the total addressable market

for products and services stands at 2.6 billion today, rising to 6.1bn by 2020. To organisations geared to deal with smaller audiences, defined by territories, the notion of a marketplace of that scale is unsettling and disruptive.

It shouldn't be. The size of the potential audience should be viewed as liberating, particularly for those willing to adapt. The Guardian Media Group (GMG), for example, started life in 1821 as the *Manchester Guardian*, in the wake of the Peterloo Massacre. Initially addressing Manchester and its environs, the newspaper slowly grew it's readership from regional to national and international, when in 1959 it dropped "Manchester" from its title and, soon afterwards, moved to London.

But with the internet, which *The Guardian* embraced relatively early, the group evolved again, rapidly transforming its outlook into one that encompassed the English-speaking world. If that consists of at least 1.5 billion



people then The Guardian, which in June reported 129 million monthly unique visitors, is still only reaching a fraction of its potential audience. With an opportunity to reach at least five times its global readership, the question for The Guardian - and other media companies - becomes "How do you rethink editorial/creative and commercial realities as you grow?" True, the group still loses around £20 million a year, but GMG has adapted well to the fundamental, counter-intuitive (to traditional business thinking) rules of the networked economy: first, grow your audience; next, deepen engagement; and only then will revenues follow.

Replacing legacy business models with the principles of the networked economy requires companies to reappraise, by orders of magnitude, not only who they can serve, but the range of services and modes of delivery that are now possible. Many are baffled by the scale of businesses like Google, Facebook, Twitter and Snapchat, which have audiences measured in the hundreds of millions or billions, with levels of engagement that have people returning multiple times a day. The fact that all of these companies built up the first two metrics (audience and engagement) before generating significant revenues doesn't make them any less confusing to a traditional business, founded on the model of restricted distribution; particularly when only a tiny faction of their audiences actually pays to use them.

Within the startup world we always like to believe, hubristically, that we're smarter than legacy companies. The truth is rather different

For incumbents, the principal lesson from the level of success achieved by the likes of Apple, Google, Facebook, Cisco and Uber – all of which have market caps of between \$40 billion to \$745bn (£26bn to £477bn) at the time of writing – is that you have to be prepared to embrace extraordinary risk. All of the above are venture-capital-backed businesses themselves, and adopting the model of "venture economics" is another way for large, legacy companies to navigate their fear of the dark.

Given the scale of the distribution opportunity today, as a VC you're essentially saying to almost any company you invest in: "Show me what you can do for six billion people." Uber, for example, first solved the unit economics of one city (San Francisco), followed by a second (New York) - and from there set out to replicate the model for more than six billion smartphones globally. In practice, for traditional firms this translates into taking the long view, and accepting that the 62 per cent of the capital that they'll get no return on (because 62 per cent of the most successful VC investors' capital has a 1x or below return), enables them to take a level of risk that is a fundamental requirement for creating blockbusters. Similarly, just as VCs have effectively given startups licence to invest relatively large amounts of capital in pursuit of longer-term goals, so incumbents must get used to the notion that building audience and engagement will necessarily incur hefty revenue losses.

In the world of corporate innovation,

there are few better examples of venture economics at work than Apple. When Steve Jobs returned to the company in 1996, Apple was on its knees, with hundreds of products in varying stages of development. He stripped away the complexity to focus on projects with breakout, blockbuster potential. The "Apple approach" is to allocate +/- 80 per cent of capital and resources to existing blockbusters - vital for cash flow, brand and maintaining audience - and then assign the remaining 20 per cent to "moonshots", the vast majority of which won't pass the napkin-sketch phase. But that's immaterial, when your moonshots have included the iPod, iPhone, iPad and now the Apple Watch.

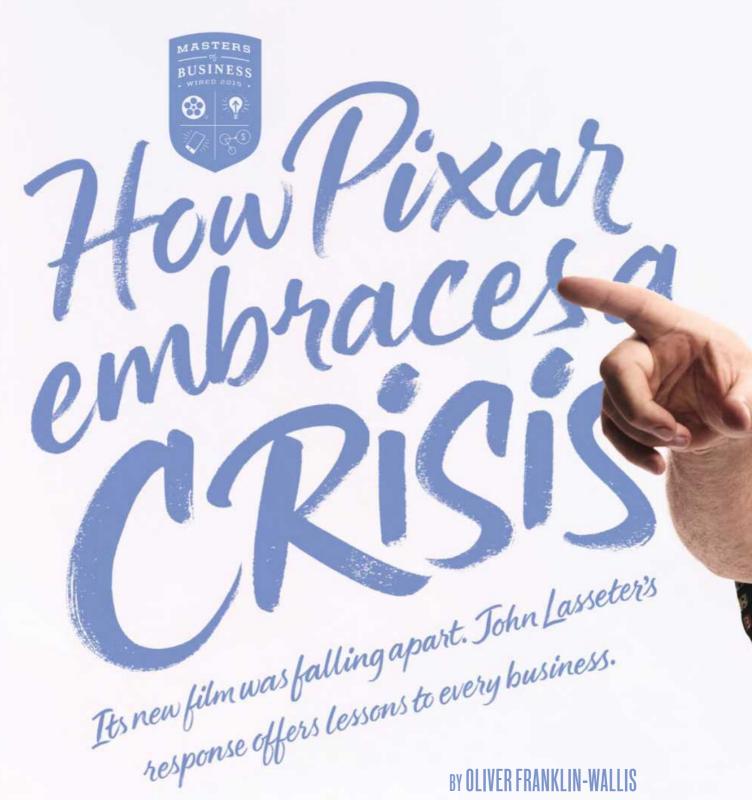
A closer-to-home example is British Gas and what it has achieved with Hive Active Heating. In a still fledgling market, its smart heating product, launched in 2013, is already the UK's leading connected thermostat. British Gas, whose earliest incarnation was founded in 1812, did two things to seize the opportunity. First, it partnered with a startup, AlertMe (in which I was an investor, as a then-partner at Index Ventures), later acquiring the company. Second, it created a new division called Connected Homes, housed in separate offices in the heart of Central London, and gave the team end-to-end control of technology, product and marketing, to bring Hive to market - evidence, if it were needed, that a 200-year-old company can move at the speed of a startup.

Within the startup world, we always like to believe, hubristically, that we're smarter than legacy companies. The truth is rather different. As argued in *Reverse Innovation*, by Tuck School of Business academics Vijay Govindarajan and Chris Trimble, they may call innovation different things, but giants like General Electric, Deere & Company, Procter & Gamble and PepsiCo know exactly how to do customer development and build minimum viable products.

When we talk about iconic disrupters today, we usually mean the likes of Apple, Google and Facebook. But those companies are less than 40 years old. By contrast, institutions like Barclays (325 years old), The Guardian (194), GSK (c170), and Marks & Spencer (131) have all faced down genuinely existential threats, including two world wars and the great depression of the 1930s, and adapted to world-changing technological breakthroughs, such as the emergence of electricity.

In our rush to laud the disrupters we have perhaps forgotten the ingenuity and innovation required to prevail across multiple generations – while, crucially, adhering to the core values that inspired greatness in the first place. The reality is that in embracing the fundamentals of what we now call the networked economy and the rules of venture economics, truly great companies have not just been reinventing themselves throughout their existence, but protecting their futures against the darkness too.

Saul Klein is a founder (LoveFilm, Seedcamp, Kano) and entrepreneur (Skype), with over 20 years' experience starting, building, exiting and investing in businesses globally. Most recently, he was a partner at Index Ventures



PHOTOGRAPHY: CHRIS CRISMAN LETTERING: RUTH ROWLAND







John Lasseter's

toys - including

Toy Story's green

provided helium-

induced voices

aliens, for which he

office is full of

Lasseter is standing on the main stage of the Anaheim Convention Center in California in front of thousands of cheering Disney fans. It's August 2015, the opening day of D23 Expo, Disney's biennial fan event, and the audience is a sea of Mickey Mouse ears and *Frozen* princesses, *Star Wars* lightsabers and *Captain America* shields.

A 58-year-old with round rimless glasses, an open, friendly face and the figure of Lots-o'-Huggin'-Bear, Lasseter is chief creative officer of both Pixar and Disney Animation Studios. But here, a stone's throw from the original Disneyland, the fan reactions might lead you to believe you were witnessing the second coming of Walt himself.

Who can blame them? Since 2006, when Disney acquired Pixar for \$7.4 billion (£4.85bn) and installed Lasseter and Pixar president Ed Catmull to impart their creative culture on its own faltering studio, Disney Animation has gone from turning out forgettable flops such as Home On The Range and Brother Bear to making critical and commercial mega-hits such as Tangled, Wreck-It Ralph and the highest-earning animated film of all time, Frozen.

"It's amazing what is happening in animation at the Walt Disney Company. Two incredible studios," Lasseter says to the crowd. He's talking to the audience, but also to his colleagues from Disney and Pixar, who pack the front section. "I'm so proud of this

place." After previewing Disney's upcoming slate – including a crowd-frenzying appearance from Dwayne "The Rock" Johnson to promote *Moana* – Lasseter turns to Pixar.

"For the first time, we have not one original Pixar feature film coming out this year, but two," he says. "And beyond those two films, we have the strongest slate of films we've ever had." Lasseter is exuberant; after disappointing reviews – at least by Pixar's phenomenally high standards – for 2011's Cars 2 and 2013's Monsters University, this spring's Inside Out has been a phenomenal success, earning more than \$770 million at the box office

(Pixar's second highest ever) and receiving the studio's best reviews since *Toy Story 3* (2010). If this month's *The Good Dinosaur*, released on November 27, is anywhere near as successful, there's a good chance that Pixar's toughest competition at the

Oscars this year will be itself.

By any standards, Pixar's success rate is astonishing. Consider: the company has made only 15 feature films (*The Good Dinosaur* is its 16th). Of those, seven have won the Academy Award for Best Animated Feature (the studio with the second most wins, DreamWorks, has two); in total, Pixar has won 12 Oscars and gained another 30 nominations. Combined, its output grossed more than \$9 billion worldwide and

films such as *Toy Story*, *Finding Nemo* and *Wall*E* have given us some of the most enduring cultural touchpoints of the last 20 years. Clearly, Pixar has a secret, and that secret is now working wonders at Disney Animation, too. The question is: what?

On stage at D23, Lasseter finishes his Inside Out presentation, then moves on to talk about Pixar's latest film: The Good Dinosaur. "Ilove this film," he says. "It's gone through an amazing transformation." What most of Lasseter's audience doesn't know is the full extent of that transformation during its five-year development. The Good Dinosaur has proved itself to be one of the studio's most challenging films ever. For anyone interested in learning the secret to Pixar's success, it's a good place to start.

From the outside, the history of Pixar reads like an unrivalled run of successes. But, peering inside, a truer history of Pixar suggests a repeated string of failures, occasionally punctuated by the release of a hit movie.

Embracing failure is a business cliché, but Pixar's unique approach to failure to pursue it obsessively throughout the creative process, embrace it and in doing so create films that never fail - can be traced back to 1999's Toy Story 2. Disney, which in those days distributed Pixar's films, had initially ordered Toy Story 2 as a direct-to-video release, but Lasseter and Catmull refused to compromise on quality and pushed for it to be shown in cinemas. As the release approached, Pixar's senior team - who had been busy making A Bug's Life (1998) - realised the film was in terrible shape. With nine months until deadline, the studio decided to perform an overhaul. Staff worked late into the night, seven days a week, rewriting the film. The effort wasn't in vain: Toy Story 2 ended up being yet another hit. The gruelling episode has attained almost mythical status within the company, and has been followed by a string of similar resets.



THINK LIKE PIXAR FIND WAYS TO FOSTER NEW TALENT

Every Pixar film opens with a short, which are used to experiment with new film-makers and test new tech. For *The Good Dinosaur*, Lasseter picked Sanjay Patel, 4l, after seeing his artwork in a Pixar hallway. Patel's *Sanjay's Super Team* is about a young Indian boy. "Everybody at the studio gets excited about shorts, because they're so artistically free and push us technologically," Patel says.

When a Pixar film doesn't reach its own high standards, they start over.

"One of the things that happens with every Pixar film is that every single one of them is crazily difficult to make to the point where they're pretty much a disaster most of the time," Lasseter says, sitting in the lobby of Disneyland's Grand Californian Hotel the morning after his presentation. "We are always having to make changes to the story. But we don't panic. We trust the process and trust ourselves that we'll work through."

In the summer of 2013, Pixar was in another such crisis. Its next original film, *The Good Dinosaur*, wasn't working. Many of Pixar's films start with a simple "what if" premise, like "what if toys were alive?" The new film, pitched by Bob Peterson, a Pixar veteran who co-directed *Up*, was equally simple: what if the asteroid that killed the dinosaurs had missed Earth? The story focused on Arlo, a young apatosaurus, and a human boy named Spot. In the film, dinosaurs evolved to be talking, social creatures but humans remained primitive.

"The vision from the beginning was to do a 'boy and his dog' story," says Lasseter. "I loved the idea. Pixar doing a dinosaur movie? This will be fun." But after three years in development and with only a few months before its scheduled May 2014 release, the film had lost its way. "It had become complicated," Lasseter says. "This happens a lot. You drown in complicated thoughts and you don't have time for personality and character and emotion." Even worse, the film-makers had lost confidence in it.

Lasseter and Catmull made a drastic decision: to push back the release date until November 2015, and redo the film from scratch. Pixar operates on releasing one original film a year and a sequel every other year. Delaying *The Good Dinosau*r meant that 2014 would be the first year without a film since 2005. For Pixar, Catmull says, delaying was an important statement.

"You're signalling to people inside and outside the company that we will do what it takes to make sure the films are very good. That's what makes this place different," Catmull says.

"What's interesting about Pixar is that the morale of the studio is directly connected to how everybody feels the movie is creatively," Lasseter says. "If their gut is telling us it's not good enough yet, we feel it. And that was the feeling with *The Good Dinosaur*. We were all looking at it, we just couldn't put our finger on it, but it wasn't quite working. That's when we shifted it around."

The lirst postep

was to replace Bob Peterson as director.

Although changing directors is rare (and sometimes messy) in Hollywood, Pixar films often experience crew changes midway through production: *Toy Story 2, Ratatouille* and *Brave* underwent similar changes. "After a while you can get worn out, and the people in the middle of it lose perspective. At that point, it helps to bring in fresh voices," Catmull says.

A softly spoken, grey-bearded West Virginian, Catmull didn't just found Pixar: he pioneered the computer graphics that made its films possible. He's also known for his deft approach to management; his bestselling 2014 book *Creativity, Inc*, written with Amy Wallace, was widely praised by many CEOs, including Mark Zuckerberg, for its candour and creative insight. ("Ed is kind of everybody's Dad," Lasseter says.)

Starting over on such projects is difficult, he says, but vital for the creative health of a company. "You can fall into the trap that not wanting to hurt somebody's feelings becomes the most important thing," he says. "Getting the story right is the most important thing."

To replace Peterson, Lasseter chose Pete Sohn, a long-time Pixar artist who had directed the short *Partly Cloudy* in 2009. Sohn, a boyish 38-year-old New Yorker, also provided the visual inspiration for Russell, the boy scout in *Up*; like Russell, he has an eager demeanour and is rarely seen without a baseball cap.



THINK LIKE PIXAR PAY ATTENTION TO WELL-BEING

Lasseter and Catmull used to be at Disney on Mondays and Tuesdays. Then they realised Disney staff were coming in on Sundays to prep for Monday meetings. "I can't do that to families," Lasseter says. They now spend Tuesdays and Wednesdays at Pixar.





Sohn had been a story artist on the initial draft. Now, Lasseter entrusted him – a first-time feature director – to rescue *The Good Dinosaur*. "We don't assign directors to movies; we bet on people who are great storytellers and want them to reach into their potentials," Lasseter says. "I plucked Pete out of story and animation because of his charm and incredible humour. I said, I thinkyou'd be great at making movies."

Sohn, along with veteran Pixar producer Denise Ream, *Inside Out* writer Meg LeFauve and new head of story Kelsey Mann, went back to the original pitch and began conceiving an entirely new story. To do so, they retreated to a small conference room, known as the War Room, and started thrashing out





THINK LIKE PIXAR DON'T FOCUS ON ONE IDEA

Employees always have to pitch three ideas. "You don't want to put all your emotional eggs in one basket, because if it doesn't work, it's wasted," Lasseter says. Something considered a secondary idea could prove a winner later on.

ideas. "It was about boiling it down, and trying to find that one emotional core of the story," says Sohn.

"We knew that fundamentally we still wanted to tell a 'boy and his dog' story," says Mann, who worked in TV before joining Pixar for *Monsters University*. "We kept some small bits and pieces but everything else we started fresh."

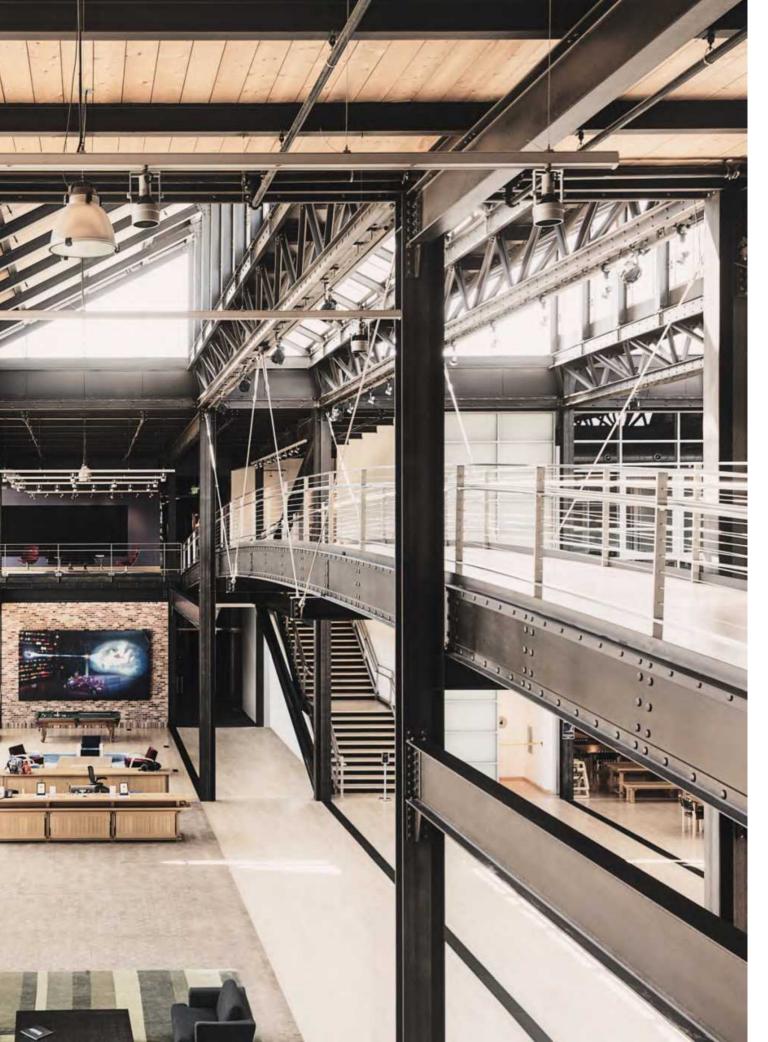
Pixar is based in the small industrial town of Emeryville, 15 minutes' drive across the Bay Bridge from San Francisco. A giant Luxo lamp and ball—the stars of the studio's first ever short, 1986's *Luxo Jr.*—stands proudly outside the main building. Designed by former Pixar CEO Steve Jobs, and renamed after him in 2012, the Steve Jobs

Building is laid out to foster serendipity: a sprawling central atrium houses a café, post room and screening rooms, the idea being to encourage colleagues to bump into each other and spark conversation. (Initially, Jobs had only wanted two bathrooms, one for each sex, also in the central atrium. This was deemed a design too far.) "You really do have chance encounters at all times," says Catmull, sitting in his office. (Catmull's modestly styled space couldn't be more different from Lasseter's office next door, which is lined floor to ceiling with toys and model train sets.) "The other thing that works about it is that if something good happens, then the structure of the building means the energy affects the whole place."

Animation takes place on the ground floor in the Lower East Side (the building, and the entire Pixar campus, adopted New York nicknames early on). Employees are encouraged to decorate their own workspaces, often to extremes – in the nooks and hallways are offices decorated like ornate temples, a Mexican taquería and an aeroplane crashed in a jungle. The spaces between the offices



The lobby of
The Steve Jobs
Building. Every
detail – down
to the colour
of the bricks
– was chosen
by Jobs to
instil creativity











Left, from top:
story artist Rosana
Sullivan storyboards
a new scene for The
Good Dinosaur, PostIts on the wall of the
War Room outline
plot points; director
Pete Sohn views
an early reel of the
rebooted film

Below: film editor Stephen Schaffer watches the latest cut of the film





THINK LIKE PIXAR CREATE YOUR OWN BRAINTRUST MEETING

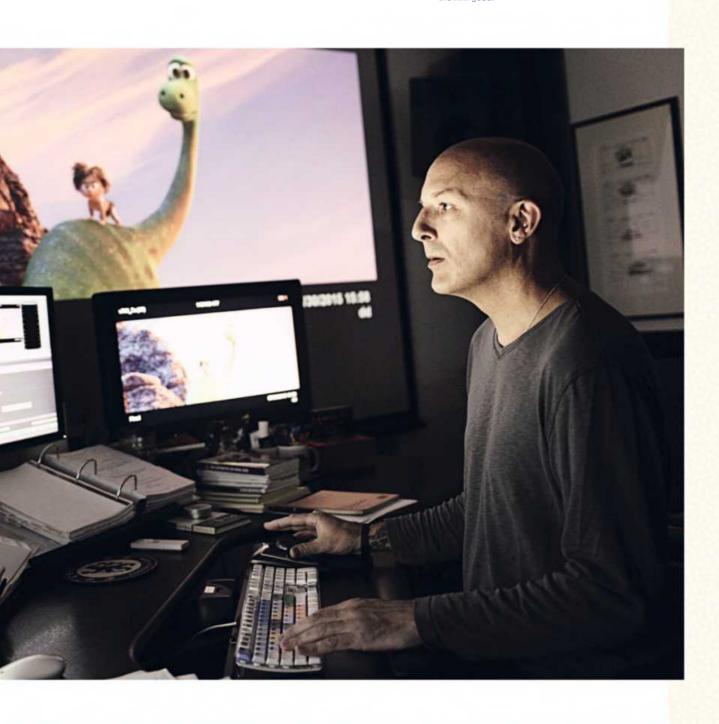
"The general notion is built on four principles," Catmull says. Those can be more simply boiled down to: surround yourself with smart people, then allow them to speak freely. A Braintrust
meeting is peer
to peer, not boss
to employee.
That means no
business talk
or executives;
although Catmull,
or Pixar president
Jim Morris, often
attend, they don't
give notes, which
might stifle ideas
in the early stages.

I. Remove the
power structure.
In braintrust
meetings, all
decisions are left
to the director.
"Some directors are
looking at people
who have been very
successful, so there
can be deference."
Deference =
self-censorship.

2. Create an attitude of shared ownership. "Let's say two film-makers are friends," says Catmull. "Lots of people value their friendship over the film. So they pull back. Here, we understand that the best thing we can do for our friend is make the film good."

3. Be able to give and listen to honest notes. Part of the requirement of creating a candid work culture is the ability to listen and accept feedback, as well as giving it. That's difficult.

4. Don't get
complacent. "It's
part of human
nature to avoid
uncomfortable
situations,"
Catmull says. "The
challenge is to keep
candour strong
and ever-present."
And if the meeting
isn't working, fix
it; it's important to
add fresh voices.



hide bars, hangout areas, and a stage for employee bands. It's a creative nirvana.

The campus also includes several other buildings, a football pitch, pool, basketball court and gym. There's also Pixar University, which trains employees and offers creative pursuits, with classes ranging from painting to t'ai chi.

The War Room is on the Upper West Side. The walls are covered in Post-Its,



scrawled with notes and sketches of every scene, and its current status in the animation process.

The new pitch had a simpler premise: after losing his father, Arlo is swept away in a river and washed up far from home. There he meets Spot, who helps him return. The pitch - clearer and with a rich emotional core - was approved.

The next step in making any Pixar film, before the real story work or any art can begin, is research. Lasseter is obsessed with it. "I drive every team to do exhaustive amounts about whatever story. I will send them to every corner of the globe," he says. On the family road trip that inspired Cars, for example, Lasseter found himself photographing the cracks in the asphalt along Route 66 ("I'm sitting on the side of the road taking pictures. It's nutty."). For Ratatouille, the film-makers trained as chefs in three-Michelin-starred restaurants. For Inside Out, which takes place inside a girl's mind, the team studied psychology and neuroscience. "From the research you get ideas for stories and characters and plot points and details."

For The Good Dinosaur, that meant going out into the wild. Sharon Callahan, who had joined the film as director of photography during the reboot, knew just the place: as a landscape artist in her

spare time, she often spent weekends painting the mountains of the American north-west - particularly Montana and Wyoming's Grand Teton National Park.

"We kept saying, 'Let's go get lost'," says producer Denise Ream. "We wanted to know what it would be like to experience what happens to our character." Sohn, Ream and the crew spent days in Grand Teton National Park, including rafting down the Snake River to research the film's river sequence. They also visited a cattle ranch; the experience, a first time for many of the crew, inspired the addition of a family of Tyrannosaurus rexes to the script.

Out in the wilderness, Sohn was struck by the beauty and danger of nature. "The river guides were very knowledgeable about survival. They would go, 'Look at that, a landslide happened down here.' We were looking at something so beautiful, but there was something really dangerous going on. We started to see that nature itself was more than just the background. It became a character in the story."

In the Art Room, the walls are covered in concept art for the film, alongside dozens of photos from the research trip; scrub, trees, waterfalls, rock formations, all chronicled in minute detail.

The setting also created one of The Good Dinosaur's biggest challenges. For the look of the film, the crew had been inspired by nature documentaries and movies such as Carroll Ballard's Black Stallion (1979) and Never Cry Wolf (1983). "A nature movie has never been done in computer animation, mostly because going out into nature is one of the most challenging things to do technically," Lasseter says. To make the natural setting feel lush and dangerous, the studio decided on an ultra-realistic style. "We wanted to make it feel like it was photographed," Lasseter says. "Actually, I believe that his word of advice was: 'I don't want it looking photoreal, I want it looking better than real," laughs Callahan.

Pixar has always pushed the boundaries of what's possible. Before it was an animation studio, Pixar was a tech company, spun out of LucasFilm's computer-graphics group back in 1986 and bought by Steve Jobs as a computerhardware business. It wasn't until



THINK LIKE PIXAR

CONSTANTLY REVIEW THE PRODUCT

Every Pixar film goes through an intensive process of iteration, testing and further iteration. When it isn't working, share it; you can never have too many creative voices airing opinions on a project. You never know where a breakthrough will come from.

the hardware business failed that it embraced its film-making talent. Ever since Toy Story, the first film entirely animated on a computer, each title has surpassed the previous technically. But The Good Dinosaur's vast wilderness setting - combined with an accelerated production schedule - presented the animation department with its most difficult challenge yet.

"That feeling of vastness in the film, that's not something we had done before, nor is it very easy to do on computer," says Callahan. Rendering enormous landscapes presents a massive computational challenge. Typically, animated films use set extension: the main portion of a scene is animated in 3D, whereas the distance - the sky, say - is a flat painted image. For The Good Dinosaur, Sohn and Calahan wanted to include a number of sweeping helicopter shots, which meant rendering the entire landscape in 3D.

The team sourced topographical data of the Grand Teton National Park from the US Geological Survey. Using the relief data, they replicated 260km² of the landscape, and used programmatic generation to populate it with wildlife.

"We used it like a live-action film would; we could go out and scout locations to find shots," Calahan says. The animation department

Sat permanently

1.5m-tall ball is

a light-up 5m-

then tweaked the landscape and wildlife as needed.

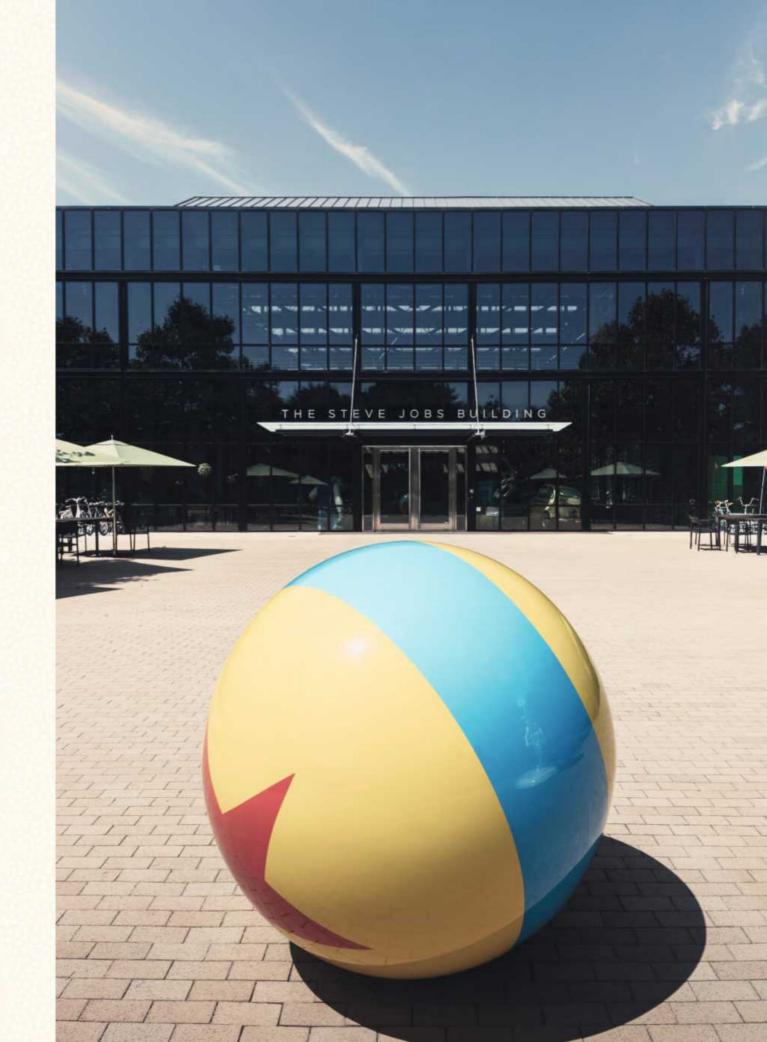
The result: The Good outside The Steve Jobs Building, this Dinosaur is the most visually stunning Pixar film yet. accompanied by Among its other technological breakthroughs: advances in tall Luxo Jr. lamp volumetric clouds, which filter and scatter light like the

> real thing, and water and dust effects. "When I looked at the footage, it took my breath away," Lasseter says.

The new pitch for The Good Dinosaur

approved, the next step in every Pixar film is story reels: a rough cut of the film, using sketches and temporary voices, so the film-makers can watch the film as it's made. During this process, every scene - from the dialogue down to the tiniest character expression - will typically go through thousands of iterations. Every line of dialogue and strand of hair are refined and perfected again and again.

At the heart of Pixar is the Braintrust, a rolling group of the studio's best creative minds which helps guide every film during development. The group's members change, but it grew out of the core team who worked on Toy Story and now make up Pixar's most acclaimed directors: Lasseter, Andrew Stanton (director of Finding Nemo and



Wall • E), Pete Docter (Monsters Inc, Up, Inside Out) and Lee Unkrich (Toy Story 3). (Joe Ranft, a founding member who directed Cars, died in 2005.)

"The Braintrust isn't a particular set of people. It's what we call the group that gets together to address a problem," Catmull says. It meets every 12 weeks; meetings start with a screening of the most recent cut of a film. After lunch, the Braintrust provides notes on what works, and what could be improved.

"The key thing is: no mandatory notes," says Lasseter. That foundation – the fundamental principle of candid, constructive feedback – goes back to Lasseter's early experiences with Disney "when it was still an executive-driven studio", where animators were given mandatory notes by high-ups.

"My note doesn't carry any more weight than an animator's. No one has individual ownership of anidea, because someone will spark something and you build upon it – so then, at the end, what you have is this feeling that everybody has shared ownership, and being proud of the whole thing."

It's easy to talk about removing authority in theory. But for Sohn, a first-time director, pitching to a room full of Oscar-winners wasn't easy.

"The speed we had to work, we were showing stuff that was really rough. We would never usually show this early," Sohn says. "But all these directors have so much experience, they know exactly what your intent is. So you can be vulnerable in front of them. You might show something that they might say, 'That's a great idea', or 'You know what? That's not as clear as you think.' But then they would offer up other ideas, or experience. Andrew might say, 'We have gone down that route before on *Finding Nemo*.' It would always be, 'This is something to try.'"

Sometimes even minor suggestions can push an idea forward. During an early Braintrust meeting for *The Good Dinosaur*, Sohn read the new script to the room. "We're waiting to hear: what do they think? Are we onto something?" Mann says. "And I remember around the first or second scene, I saw John write on his script: FUN. And we knew: 'All right, they're into this.' We had a stamp made of John's handwriting of FUN to remind ourselves to have fun with the film. Sometimes, that's all it takes: one little word to give you inspiration or the juice to keep going forward."

Pixar also screens each work in progress to different departments – lighting, development or animation – for



Pixar and Disney animation president Ed Catmull in front of the colour script for *Inside Out*

further notes and feedback. "We're constantly watching the movie to see: is it good? If it's not, we fixit," Mann says.

"You keep tearing it down. We've cut a lot of great moments, not because they weren't great, but because they weren't right for the film." The process requires a strong mindset, and can be fraught. "It takes a really strong director to let go of things that they love." To remind its



THINK LIKE PIXAR SHARE YOUR EXCELLENCE

Pixar engages with the animation community: in March 2015, after the opening of *Big Hero 6*, it released its Renderman software free for non-commercial use. "The art pushes the technology, and the technology inspires the art," Lasseter says.

creatives to persevere, the studio often screens early story reels from its most successful films. "It's so helpful to see that even the films we now think of as classics, at one point or other, were not working," says Mann. "It's reassuring to know: 'Oh, we're not unique.' This is a process. And in the end, we're going to have a great film just like that one was."

The process hints at the simple but profound secret of Pixar's success: behind the loveable monsters and talking cars, everybody at Pixar is a perfectionist. "Everything – everything – is geared towards making the best film we can make," says Mann. "That's not true at other studios; they have lots of other priorities. At Pixar, the film is the number-one priority – for everyone."





THINK LIKE PIXAR **DELEGATE**

"We delegate to each other. And so Andrew Stanton, Lee Unkrich and Pete Docter are all making their own movies, but they take a little bit more of the creative leadership load, so they can free up time for me to direct *Toy Story 4,*" Lasseter says.

The Pixar process is not flawless. If anything, The Good Dinosaur proves that even a studio with a dozen Oscars can suffer from major issues when it's not expecting it. For all its triumphs, Pixar faces mounting pressures, both internal and external. Among the few that Catmull identifies in Creativity, Inc: rising production costs and external economic pressures, including every studio's falling DVD sales. In particular, he notes that the candid culture inside Pixar takes constant maintenance. Among his solutions: the annual Notes Day, during which every Pixar employee is encouraged to suggest changes to how the company works.

Lasseter and Catmull also now have less time at Pixar, spending two days

a week at Disney Animation over in Burbank. As chief creative officer, Lasseter doesn't just oversee films, but provides input over almost everything that Disney does, from toys down to the company's theme-park division. "John time" is a precious commodity. What's more, he recently announced that he will be returning to co-direct a fourth *Toy Story*.

That announcement points to another abiding concern: at D23 Expo, the studio teased a number of sequels, including *Toy Story, Finding Dory, The Incredibles II* and a third *Cars*, but only one new original film, *Coco*, about the Mexican Day of the Dead. (Those fears may yet be unfounded. At Pixar, there were hints at originals in the pipeline; there are always several in development.)

"Roughly, we try to have two original films to each sequel," says Catmull. "Sequels are financially less risky. But if that's all we did, we would become creatively bankrupt. *Up, Ratatouille*, the trash compactor that falls in love – these are high-risk ideas. So in order to take the high risks, which is very important to us, then we do things which are lower risk. We have to make sure we're also smart as a business."

For Catmull, the more pressing concern – the one that occupies him most days – is working out how to ensure the culture which has led to Pixar's success survives as the industry changes and staff come and go. Just like Walt Disney, Catmull and Lasseter will one day retire, and Pixar must live on.

"What you don't want are people trying to repeat what we did to begin with, because we can't," Catmull says. "Instead, it's a mindset: that everyone here owns the films we're working on. Our whole history has been about changing and adapting. If the idea we had isn't working, we'll change at every level, whether it's management, production or the technical side."

To Lasseter, making *The Good Dinosaur* has re-energised Pixar, and doubled down its commitment to telling great stories. "It was hard for the studio, but it wants to be making great films," says Lasseter. "We have this simple philosophy that quality is the best business plan."

Of course, there's always an outside chance that, despite all their hard work, *The Good Dinosaur* will fail, and Pixar's run will come to an end.

"Nobody wants to be the one to break the streak," says Ream. "Luckily, I work with a ton of people who will go the extra mile to make the film better." It's a quiet moment, at the end of a long day; the WIRED photo shoot is finished, but Sohn and Ream are going back to work on the film, which is still only 50 per cent rendered. There's plenty to do before release. "My thing, at the end of the day, is I look at it like: 'Is this the best we can do?" says Ream. "And I think every single person here, would say: 'Yee'." \textsquare."

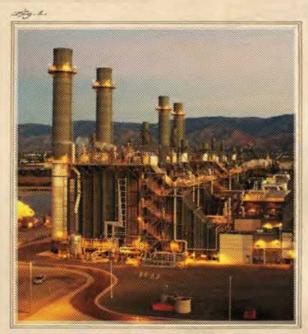
Oliver Franklin-Wallis is assistant editor at WIRED, and edits the Play section



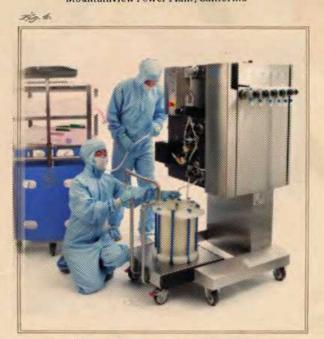
HOW AN INDUSTRIAL GIANT THINKS SMALL

GE Appliances used to spend years - and millions - developing new products.

Today, its spin-off, FirstBuild, crowdsources and creates in months, at a fraction of the cost



Mountainview Power Plant, California



ÄKTA ready chromatography system



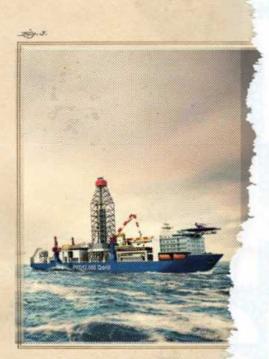
GE90-115B jet engine



9HA gas turbine rotor

By Tom Vanderbilt

Photography: Cody Pickens



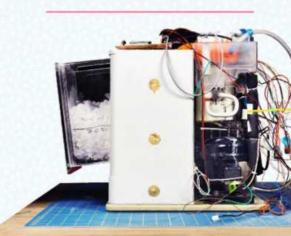
Gusto MSC PRD 12000 ultra-deep



Sensor Dry tumble dryer

THE NEW GENERAL ELECTRICS.

Opal, GE's nugget ice machine, was designed by the crowd in a matter of months, rather than by engineers taking years



THE LOUISVILLE
FIRE DEPARTMENT,
CLAD IN BOOTS
AND BLUE UNIFORMS,
HAS BEEN
SUMMONED TO THE
HEADQUARTERS
OF FIRSTBUILD, ON
THE CAMPUS OF
THE UNIVERSITY
OF LOUISVILLE
IN KENTUCKY,
WHERE AN ILLEGAL
ACTIVITY IS
TAKING PLACE.

The activity in question is the cooking of pizzas which, every few minutes, come bubbling and steaming from a small wall-mounted oven. The last time FirstBuild, a small startup making novel appliances, tried to make pizza, the ensuing smoke triggered an alarm – wired to the city network – scrambling fire engines to the address. "You're not allowed to cook unless it's under a hood," says Natarajan Venkatakrishnan, FirstBuild's director (he goes by "Venkat"). "The fire marshal said: "The next time this happens, I will cite you."

There is no hood because FirstBuild is trying to build something quietly revolutionary: an indoor, ventless and doorless pizza oven for the home that mimics the extreme heat of the wood or coal-fired ovens traditionally found in pizzerias – at a fraction of the cost. A traditional home oven has two "rods"

or heating elements – this one has 20 to 30. Even as the inside temperature reaches 500°C, the outside of the oven is cool. The company is researching an app that would allow users to input what sort of pizza they would like – from charred Neapolitan to Chicago-style pan – triggering the proper heat profile.

Since the first episode, engineers added a catalyst – not unlike the exhaust-scrubbing device found on cars – that appears to have solved the smoke problem. And instead of issuing citations, the fire and rescue personnel are busily eating slices topped with mozzarella and prosciutto – a smart bit of diplomacy by FirstBuild. "What's the cost range?" the fire chief asks between mouthfuls. "We might want to take the display model to the firehouse."

The plucky startup troubling convention is hardly a new story, but what is remarkable is that FirstBuild is actually an offshoot of GE Appliances, the behemoth with sales of \$6 billion (£4bn) a year. Its factory, Appliance Park, is so massive that its car park has traffic lights to manage the flow of 7,000 workers coming and going. And Venkatakrishnan is no T-shirt-clad incubator graduate but an Appliance Park executive. He shuttles between the "mother ship", as he calls it, and the 50-employee FirstBuild like a buttoned-up headmaster sneaking downtown at night.

FirstBuild is an experiment by parent company GE that combines the power of so-called "open innovation" – the idea that new products can come from outside a company's own walls – with the speed of additive and low-volume manufacturing, topped off with the novel promise of crowdfunding, or getting a passionate, self-selecting market of consumers so early to adopt that they are willing to buy something before it has even been built.

GE Appliances, Venkatakrishnan says, is optimised for large-scale efficiency: squeezing out waste from huge production runs. Generally, the company will not even look at a product unless it's making 50,000 units a year. This is good, he says, for churning out products in an established market. But in terms of innovation, he says: "It's like a battleship," taking a long time to start, a long time to stop and a long time to change direction.

"Launching a refrigerator takes two and a half years from mind to market," Venkatakrishnan says. Or imagine a new product, like a slushie maker. "It takes six months to a year to do the engineering feasibility," he says. "Then it takes a year and a half for us to go into the system to make a decision. Then you get a team together and scale that up, which takes another year and a half." Four years later, you have your slushie maker. And so do your competitors.

By contrast, consider FirstBuild's most successful product to date, a small machine called Opal that produces "nugget ice". These are small, soft pellets of ice popular at fast-food restaurants and convenience stores in the south of the US. Prized for their cooling ability (the ice has more surface area) they can, curiously, also be comfortably chewed. It was a niche market, with an uncertain consumer demand for making nugget ice at home. "There was a lot of risk,"



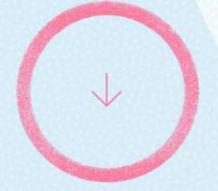
🎓 Kevin Nolan, GE Appliances' vice president of technology, takes a tour of FirstBuild's microfactory in Louisville, Kentucky

says Kevin Nolan, vice president of technology at GE Appliances and First-Build's other key driver. To put out a new product introduction, or NPI, at Appliance Park, he says, is a bet of many millions of dollars. "How much have we spent on Opal so far? Maybe \$50,000."

Five months before WIRED's visit, FirstBuild had announced on its website the Nugget Ice Challenge. Community members were invited to present a 2D design rendering for an affordable counter-top machine that could service a family of four. The entries were voted on and, less than a month later, the winning submission – from designer Ismael Ramos in Guadalajara, Mexico – was chosen. FirstBuild then began to work on the product.

Meanwhile, community members batted around ideas online about the machine's form and function. In July 2015, Opal went live on Indiegogo not as a finished product but a piece of artifice, a rendered dream of nugget ice. "We made fake videos," notes Nolan, taking ice from an industrial machine and adding it to the Opal mock-up. By October, more than \$2.6 million had been raised by 6,281 backers. "We asked Indiegogo if we could we collect the money after the product is delivered," Venkatakrishnan says. "They said, 'No, that is now how you test people. You have to take the money up front. That means they believe in it."

"We had a big a-ha moment," Nolan says. "We didn't have a channel to talk to early adopters." GE's channel was big-box stores such as Home Depot or the mass builders who buy standardised appliances in bulk. If Opal had failed to generate enthusiasm on Indiegogo, says Nolan, "we would have killed it". But it is a success, and a curious one: a product designed over the internet by someone in Mexico (and refined by an ethereal network of enthusiasts); being built not in Appliance Park, but in a former shipping-and-receiving warehouse; marketed and sold not in GE Appliance's traditional retail outlets but on Facebook and Indiegogo. FirstBuild is questioning the very model that has held sway for decades across town. "We are saying we can hit the market if I can make 15 units a week," says Venkatakrishnan says. "Not only that, but with an investment profile that is much lower. If a product takes off, we can transition it to the mother ship," he says. "If it doesn't, it's just a bad idea."



Nugget ice, and FirstBuild's other early projects, began with an off-road vehicle costing \$100,000 and modelled on the P-51 Mustang fighter-bomber.

The Rally Fighter - based on tens of thousands of designs from thousands of participants, all protected by a Creative Commons licence - is the car that made Local Motors, the company launched in 2009 by ex-marine (and Princeton and Harvard alumnus) Jay Rogers, famous. It was Wikipedia on four wheels: rather than closed teams of designers working in labs and on private test tracks, everything was out in the open, evolving before enthusiasts' eyes.

A few years ago, Rogers was invited to speak at a GE summit by Beth Comstock,

the company's CEO of innovation, about the new world of manufacturing augured by companies such as Local Motors. It was just one in a series of initiatives, rippling through the corporate giant that looked to breach the razorwired, security-badged, NDA-shrouded world of traditional R&D and expose any number of design challenges from jet engines to air conditioners to crowdsourcing. Innovation was one of CEO Jeffrey Immelt's highest priorities; on his appointment in 2001 he ploughed a billion dollars into R&D. As GE chief learning officer Raghu Krishnamoorthy had described it, the operational excellence prized by legendary former-CEO Jack Welch was less viable in a turbulent new world of small-scale, global disrupters. With Immelt, GE was seeking to overhaul its entire culture, with mantras like "stay lean to go fast" and an emphasis on agile, "horizontal" approaches.

But innovation was not open innovation, at least not at first. In 2010, five years after it launched its Ecomagination green-tech initiative, which featured internal crowdsourcing, GE shifted gears. It opened

FirstBuild's homepizza oven uses multiple heating elements, rather than the usual two, which can then be activated selectively in order to cook different types of pizza.

THE PIZZA OVEN





OPALICE MAKER
To create its ice
maker, FirstBuild
launched a design
competition and
crowdfunded
the winning design
on Indiegogo.
The launch cost
around \$50,000.

LEARNING FAST: FIRSTBUILD'S FIRST STEPS AND THE PROJECT THAT INSPIRED IT

the project to outside innovation (with Brightidea), putting hundreds of millions of dollars into harvesting ideas - such as the energy-monitoring startup PlotWatt. Suddenly, you could see Immelt sharing the stage with the founders of startups whose revenues were beneath even rounding errors in GE's \$157 billion portfolio. "GE has to be good at ways to take ideas and make them big, reliably and quickly," Immelt noted at one conference. Where every app developer wanted to become the next GE, GE wanted to become like an app developer. "We're saying it's OK to try things earlier, and bring customers in earlier," Comstock said. "You're giving people the freedom to move faster to make more small mistakes."

GE was by no means on the leading edge of open innovation (Procter & Gamble reported that, by 2006, more than 30 per cent of its intellectual property had input from the crowd). But it now seemed to be going all in. Its FastWorks programme, inspired by Eric Ries's concept of the "lean startup", looked to bring the agile processes of software – start fast, fail fast, learn fast – to a company whose roots stretch

back to Thomas Edison. It paired with Kaggle, the platform for data-scienceprediction contests, on a competition to improve aircraft efficiency. It spent \$30 million on Quirky, the website that paired inventors with manufacturers, to probe the burgeoning internet of things market and opened up 20,000 pieces of IP in its patent library to Quirky's community. It put thorny engineering challenges on platforms such as GrabCAD, and found solutions from people who were not only not GE employees, but often came from other disciplines. With FirstBuild, GE was further refining its approach. Where Quirky often sent inventors to Chinese factories, Rogers imagined a platform integrated within GE's vast range of manufacturing assets. "We came in with a very specific methodology,"

IF A PRODUCT
TAKES OFF, WE CAN
TRANSITION IT TO
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IF IT DOESN'T, IT'S
JUST A BAD IDEA

Rogers says. "We wanted them to do open hardware development, and specifically we wanted to co-create with a community all the way through the development of a complex device."

Rogers, in essence, was asked to import Local Motors' approach - down to the layout of the factory - to a division at GE. The first thought was oil and gas, but, as he notes, "If you're blowing and going and making a lot of money, there's less desire to try new methods." He eventually came to GE Appliance, where he found "very willing partners". The early success, he says, is striking. "When GE launched its ultra-efficient water heater - a three-year development effort, and a multi-hundred-million-dollar campaign, it sold 20,000 units the first year," he says. "It looks like Opal is going to push 6,000 units in 30 days, with a three-month development cycle."

So why wasn't such a seemingly viable model launched earlier? The answer:severallarge structural changes had to happen. At the end of the 20th century, describes Henry Chesbrough, the University of California business professor who first popularised the



RALLY FIGHTER

Local Motors'
Rally Fighter offroad vehicle
was designed by
the crowd and
and built in a
microfactory. The
project proved
a key inspiration
for FirstBuild.

CLOTHES DRYER

FirstBuild also developed a machine that dries clothes by creating a vacuum to suck the vapour out. It hasn't worked well so far, but further tests are ongoing.



FOUR STARTUPS THAT HELP GE TO LEARN FASTER



. KAGGLE

GE collaborated with data-science community Kaggle to ask scientists for algorithms that could improve the efficiency of its aircraft by fine-tuning flight paths and minimising delays.



2. FIRSTBUILD

a partnership between GE and Local Motors, FirstBuild taps into crowdsourcing and micromanufacturing to create home appliances.



3. GRABCAD

GE launched a competition on the online engineering community when it hit problems with the design of a plane engine component. The winning idea came from an engineer in Indonesia.



4. QUIRKY

GE has poured
\$30 million – and
hundreds of its
patents – into
Quirky, a (recently
dissolved) New
York-based
platform that
connected
manufacturers
with inventors.

concept of open innovation, knowledge workers were growing in number and mobility, making it easier for them to strike out on their own. They were also finding more willing funding thanks to the growth in private-venture capital. There were technical innovations, too: not just the internet, but the rise of Linux and open-source platforms.

"It had to be proven that complex systems, even if they were just software, could be made by a crowd of contributors," Rogers says. At First-Build, Venkatakrishnan points to new micro-manufacturing technologies. "For \$4,000 I have a desktop thing where I can edge circuit boards that didn't exist five years ago. I've got laser cutters where I can cut metal. I've got a pick-and-place machine [used in the assembly of circuit boards]. Five years ago, if I had to make an entity to design and build and sell in low volume, where would I find the equipment?"

The rise of the maker/hacker-space movement, meanwhile, provided the community that FirstBuild taps into. In trying to bring this spirit into the world of corporate appliance development, it had to climb a steep curve of unlearning. Before embarking on a new project, says Venkatakrishnan, a big manufacturer would undertake projections of the costs of tooling and setting up assembly lines. But what if a startup wanted to create, say, a USB-powered refrigerator? "They would go to the market, buy a refrigerator, cut the case and liner and put USB ports in it," he says. "Then they would put Arduino and Raspberry Pi in the back, and you have enabled a USB-powered refrigerator. That's exactly what we did." Indeed, a week earlier, FirstBuild had issued its first royalty cheque for that

very same USB refrigerator, called the ChillHub, to a local schoolteacher who, Venkatakrishnan notes, "used to come here and work on Arduino". Everything happens faster. As Ted Lee, who heads Louisville's Office of Civic Innovation, notes, "you come in, you join, you submit an idea, you're into the IP licensing right away."

It doesn't hurt, of course, when the startup has a benefactor with deep pockets, scores of engineers and decades of experience. "It's like having a rich parent," Venkatakrishnan laughs. "Like the kid who has a car and says, 'I am self-sufficient, but my dad helps out with insurance and he pays for petrol once in a while.'" Danielle Blank, who heads LVL1, Louisville's noted maker space, says FirstBuild is "sort of like our hot sister", with glitzier tools. But she says FirstBuild is not merely a corpo-

ration's clumsy attempt at bottling the magic of garage innovation. "Venkat used to hang at LVL1 a lot," she says. "You can see at FirstBuild that they're trying to emulate the community aspect." She says the maker-space mantra is: you come for the tools and stay for the people.

FirstBuild opens its doors to anyone: during WIRED's tour, Nolan pointed to a man at a workstation and asked, "Who's that guy on the SolidWorks?" "He's a Louisville master's student," replied Venkatakrishnan (access to Louisville students is key; indeed, the JB Speed School of Engineering is building, next to FirstBuild, an Institute of Product Realization that, as John Usher, the school's acting dean, explains, will comprise a range of similar microfactories). During the run-up to Christmas, FirstBuild bristles with people making handmade gifts. "Why do we do that? Why would we let someone making a TV cabinet for their home come here?" Venkatakrishnan asks. Nolan jumps in: "The hope is we're going to find someone who is interested in what we're doing, or we learn something from them." He wants it to be the "Chelsea Hotel" of electronic innovation - random creative people rubbing together in an eclectic space.

You do not find the marginal players if your doors are closed. "When we started Local Motors, Elon Musk said that engineers don't like to share," says Rogers. "Seven years later he wants to open-source Tesla's system." By not opening up its designs, Rogers argues, a company is "hobbling its ability to move fast. Speed is the new black".



FirstBuild director Natarajan Venkatakrishnan



Sitting on a high shelf in the corner of the FirstBuild micro factory sits an industrial-looking device. "Someone had the idea you could dry clothes with a vacuum," Nolan says. "Like a Dyson?" WIRED asks. "No, like outer space." The idea came from a community member in Illinois: suck the air out and the vapour will "flash off". FirstBuild took a crack at it. It didn't work, but, as Nolan says, "we learned a lot on the physics of it."

The idea is that innovation can come from anywhere. Venkatakrishnan says he gets a number of letters each month from prisoners. "They write to us with their ideas," he says. One of FirstBuild's products, a simple but elegant oven drawer that opens towards the user when the door is opened (so the cook does not have to reach deep into the oven), came from a retired GE engineer. As Leadbeater notes, even when engineers create technical innovations, it is often the random consumers who determine their use. At an LVL1

IT'S LIKE
THE KID WITH A CAR
WHO SAYS "I AM
SELF-SUFFICIENT,
BUT MY DAD PAYS
FOR THE PETROL"

hackathon, coffee enthusiasts came up with an Arduino-powered tray to use in a convection oven for precise home roasting of coffee beans. That idea, says Venkatakrishnan, could percolate back into the 10,000 Wi-Fi-connected ovens he says GE has shipped. An app could create the proper temperature profiles. "That is not a standard algorithm for an oven," he says. "We would never have imagined you could roast coffee beans in an oven, or that you might prefer my oven because it can do that. It's like peeling an onion: you find people. They come out of the woodwork."

The ultimate hope is that the agile, low-volume techniques tested at FirstBuild might start to trickle back to Appliance Park, and to the larger corporate parent (a notion complicated by the pending sale of its Appliance division to Electrolux, which will also get FirstBuild as part of the deal). In FirstBuild's factory, Nolan hands me a small plastic clip. When the company began shipping the oven with the slide-out drawer, early users complained of a rattle in the drawer. Engineers responded by 3D-printing a mould and making a clip to stop the rattle. Nolan notes that the clip is starting to chip. As it is programmed into the CNC machine, however, he can simply print another. "I can break a whole lot of \$20 tools," he says. Start fast, fail fast, learn fast. As Nolan puts it: "Let's stop arguing and let's make it."

Tom Vanderbilt wrote about Planet Labs in issue 5.15









ot much is happening, and Supercell

likes it that way. By the end of this fine summer's day in Helsinki, €5 million (£3.6m) will have rolled into the gaming company's accounts as it does every 24 hours; but the offices are quiet. There is a pile of discarded shoes by the door: employees walk around barefoot and in socks, which might contribute to the hush. The team for the game Clash of Clans, the highest-grossing app in the world, tinker at their screens, all of them wearing headphones. "Everyone sits quietly and taps on the keyboard," according to Marika Appel, Supercell's marketing manager. Ilkka Paananen, co-founder and chief executive, adds: "Last year we hired 25 people, across five offices, so it's even less in Helsinki. That's probably why it's so quiet." There's a long queue for the pizza being handed out. It's all very reasonable.

There was a time when Supercell was sound and fury. In the summer of 2012, it released *Hay Day*, followed by *Clash of Clans*. Six months later, those titles were generating \$1 million a day. Six months after that, \$2.5 million. In April 2013, Supercell raised a \$130 million funding round led by IVP. That year, it raised \$892 million – up from \$101 million the previous year. In October 2013, Japanese telecoms giant Softbank bought 51 per cent of the company at a reported valuation of \$2.5 billion. In March 2015, Softbank purchased the rest of the shares owned by

IIkka Paananen

Supercell's co-founder intends to be "the world's least powerful CEO"

external investors. Gamesbeat reported that the valuation was \$5.5 billion.

"It's been a really great three years," Paananen says. He's tanned and wears shorts and his trademark black Supercell T-shirt. Now, he's determined to take his time: "We've taken our own approach here, which is: we like to do things very, very slowly."

You can see it in the interiors of the office. When WIRED first visited in November 2012, the team had just arrived after Nokia had moved out. The initial office space was standard zany startup chic: a room dedicated to LEGO, colourful chairs, stupid names for meeting rooms, the world-domination map showing active players around the world. The newest part of the office is very different, more a subdued members' club than a playground for nerds. The rooms currently being furnished will be more elegant still. Apart from one – a recreation of the bar that was the backdrop for a half-time Superbowl advert featuring Liam Neeson.

Slowing down makes sense. There are other gaming startups – Zynga, Rovio, King – that enjoyed explosive growth and are still hugely valuable businesses. King, for instance, has a market capitalisation of \$4.2 billion. But each of these has been unable to sustain their initial dizzying ascents.

Supercell rocketed even higher, even quicker. "We try to map out different scenarios, for whether something continues to grow or dies out," says



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very slowly'

Ilkka Paananen

Niklas Zennström, co-founder of Skype and an investor in Supercell through his firm Atomico. "Many times companies are not tracking according to the best scenario. With Supercell, they've been tracking, at least initially, according to the best scenario."

The question is whether Supercell is still tracking and where it is on the parabola. Right now, it feels like it's throttling back. That could still mean a steady ascent - or it could be the first feeling of weightlessness before the company comes down. Supercell hasn't fully released a game since 2013. It has created scores of them and killed them all. Paananen has lost count: "How many? Oh my god! Many. Let's see. We've killed... many." Games can be good, and popular on the App Store, but if they won't be played for a timespan of years, they get killed. Supercell is celebrated for toasting each of its failures with Champagne.

Gaming is a hits industry and, eventually, Supercell will need another hit. "The nature of this business is that you're going to have hits and then softer quarters or even years," Paananen says. "We like to think much, much longer term, ten years ahead. We'll keep the company small, stay organised in small independent teams and hire as slowly as possible to make sure the culture sustains. Then if you add some luck into the equation and give us enough time, we will make some great games.

"All of us have been part of companies that have grown really quickly. This time we promised ourselves that we're going to do things differently."

In an industry where novelty rules and in a startup culture where growth is worshipped, Supercell has perhaps found a way to take its own sweet time. S

upercell's rise, from the release of *Hay Day* to its \$2.5 billion acquisition, was conspicuous. But the two years before that were much more important: the company's structure and culture were forged with the hope that they would see it through decades of success.

Paananen, alongside Mikko Kodisoja, Petri Styrman, Lassi Leppinen, Visa Forsten and Niko Derome, founded the company in 2010. The team's previous company – Sumea, a mobile games developer – had been acquired by Californian games developer Digital Chocolate. Over the years Sumea had grown from 30 to 400 employees by making throwaway games for dumb phones. Supercell would be the opposite.

"The original founding idea was to do games that people would play for a long time," says Leppinen. Less *Cut the Rope*, more *World of Warcraft* - but for a much broader audience. "One of our dreams was to create games that people would play for decades," Paananen says.

David Gardner, general partner at London Venture Partners, the investment company that was part of Supercell's first round of finance in 2011, says: "What was interesting was how they wanted to doit was extremely organised." Instead of hundreds of developers, they kept it small. Each seven-person cell would create games quickly, and abandon them quickly; the only people who could kill a game were those who had come up with it.

Put all those independent cells together and you have Supercell. Paananen wanted to be, in his words, "the world's least powerful CEO". "That is something that hadn't been done historically in games," says Nicholas Lovell, who runs games consultancy GAMESbrief and is the author of *The Curve*. "The Supercell model is: trust the team. That gives them empowerment."

The first product idea was the opposite of small, though: make cross-platform games, for Facebook, tablet, mobile and the web. The team developed *Gunshine.net*, a massively

Clash of the mobile-gaming clans

While Supercell waits for its next big title to materialise, its competitors continue to release a string of worldwide hits



Supercell Founded 2010 Key Products Hay Day, Clash of Clans The Helsinki-based company banked £1.1bn in 2014. This year it has grossed about £3.68m per day. Softbank now controls 73.2



King Founded 2003 Key products Candy Crush Saga, Farm Heroes Co-founded and led by Italian Riccardo Zacconi, but headquartered in London, King debuted on the NYSE in March 2014 when revenue was around \$2.26bn.



Zynga
Founded 2007
Key products FarmVille,
Draw Something
San Francisco-based Zynga
debuted on NASDAQ in 2011;
by 2014 its annual revenue was
\$690m. Since 2010, it has
been acquiring smaller gaming
and software companies.



Rovio
Funded: 2003
Key products Angry
Birds series
The Finnish entertainment
company is currently going
through a relavitely rough
patch: its 2014 revenue
amounted to €158m, down
nine per cent on 2013.

multiplayer role playing game for Facebook, and released it in February 2011. "I didn't want to be rude," Gardner says, "but I didn't think *Gunshine* was going to be a good product."

Gunshine was a good game, but a bad fit. Facebook was a platform for broad, casual games; Gunshine was extremely complex. The same logic would apply to any Supercell game, though: people would only play for years if it was deep, yet Facebook and the web were built for the shallow.

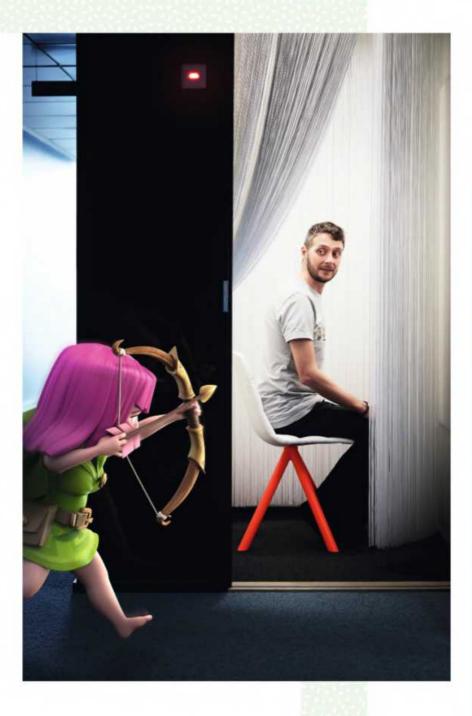
"We got that completely wrong," Paananen says. "So we threw everything down the toilet."

Every startup must have its pivot, but what's noticeable with Supercell

is how painless and quick the process was. It wasn't so much that the team pivoted the company – the company pivoted itself. "In retrospect, developing *Gunshine.net* was like a training camp," Leppinen says. "Nobody was heartbroken when we decided to make the call. You know: scrap everything, fuck this, let's move into mobile."

The beta of *Gunshine* had around half a million monthly players; nevertheless Supercell decided to kill it. The company which, by then, had raised \$11 million had scrapped its only product.

"There was a bit of pressure," Paananen says. "We have a very senior team, ten years plus of experience, raised lots of cash, and yet they still



can't put anything out..." According to Lappinen, "You could feel it in the air. It was a now-or-never situation."

In January 2012, Supercell had five games in development. Two would become *Clash of Clans* and *Hay Day*, the other three would be killed: the pivot had baked discipline and ruthlessness into the company's culture. "Supercell very nearly went bust," Lovell says. "It nearly went horribly wrong. It was a brave and gutsy move. I wouldn't underestimate how much that formative awareness, that making a radical change saves the company and informs a lot of how else they behave." The move to mobile worked for three reasons: it offered breadth – billions of devices –

'Nobody was heartbroken when we decided to make the call. You know: scrap everything, let's move into mobile'

Lassi Peppinen

Lasse Louhento

Supercell's game lead is currently trialling his team's latest title in-house

but also depth: people constantly keep their devices with them. And it was exploding as a platform – in 2011, 472 million smartphones were sold; in 2014, it was 1.24 billion. Each one of those is a new potential customer for Supercell.

Six months later, Clash of Clans and Hay Day were released. Engaging and highly polished, the games dominated the charts. What was unusual was how they stuck around; and how they continue to do so. The games were free - a strategic move to reach as many people as possible. Revenue would come from more committed gamers making in-app purchases. Supercell makes its money from gems, the currency in Clash of Clans, which can be bought with real money. Gems let you upgrade the buildings in your fort or can be exchanged for other game resources, like gold and elixir. 1,400 gems will set you back £79.99; people who spend a lot of money on gems are called "gemmers", and they keep Supercell in business. Some of the top players spend around £1,600 a month buying gems.

That may sound extreme, but unlike most free-to-play games, it's possible to play quite happily without them. Supercell doesn't force them down players' throats. "They have always had a very long-term view of the customer, which is – don't hammer them for money right away," Gardner says. "Build a game that's inherently fun and make sure that the spending experience brings pleasure rather than removing anger."

When Clash of Clans and Hay Day started growing, Supercell started building them out. "Our content is spread out, it's progression," Lappinen says. "That's how we planned it to work long term. It opens up layer after layer." Supercell hasn't just been adding extra levels to keep players interested. It's continuing to develop the games themselves. "It's our duty to keep the game fresh," says Lasse Louhento, who designed Clash of Clans alongside Lappinen. "Adding more - not content, but layers of depth." Chief Pat makes wildly popular YouTube gameplay videos for Supercell and has been playing it since its release. "It's way deeper than what it was," he says. "There were only a couple of ways to play the

game then, but now it's very different."

And this is interesting, because gaming becomes a lot less like Hollywood than it does the TV industry. If console games are the box-office events where you pay top dollar for a one-off, Supercell's games have the slow-burn longevity of a TV series. An EastEnders for the mobile world. "More and more you can see that these are not just hits," Zennstrom says. "They're more evergreens than hits. That doesn't mean that they will be forever, but they're there for a long time." At that point, the notion of people playing a game for years, maybe decades, doesn't sound so far-fetched. And the notion of a hit becomes less important. Who wants a seguel to Coronation Street when the original is still entertaining people and making money?

Television thrives on social (who shot Lucy Beale?), even in an on-demand world and, increasingly, so does Supercell. Social elements keep people coming back to the game. "The social element becomes even bigger than the game," Paananen says. "It's the reason a lot of Clash of Clans players keep coming back." People - especially younger players - make friends on the game. "For my generation, it was Facebook," Gardner says. "For my son, it's Clash of Clans." Players' cars have broken down and they have sought help by opening up Clan chat, rather than phoning their roadside assistance company. There have also been wedding proposals: one user, JNatsu, spelled out "Will You Marry Me" in Level 7 walls. (The reply, a ves, was inscribed in the intended's own base. When JNatsu, posted a screenshot of the proposal to the Supercell forum, another user replied, "This should of [sic] probably been in Off-Topic". Clash is serious business.) Paananen wants to go further with social because it also adds more layers to the games. "We really have to make them deeper and better with the social factor. The more social games are, the bigger chance they have of becoming hobbies."

"Supercell" also refers to a type of thunderstorm, characterised by a deep, constantly rotating updraft. They are known as "quasi-steady-state storms", which to some extent feed on themselves in a virtuous cycle. At this stage, the Finnish Supercell is similarly self-sustaining, through its culture and structure, which reinforce each other.

Choosing mobile as a platform means it's possible to create games which



Lassi Leppinen

Supercell's co-founder and project lead co-designed *Clash* of *Clans* with Lasse Louhento

reach billions with just a small team. Those teams make games quickly, and scrap the ones that don't work just as quickly. When a game takes off, that cell keeps developing its own game, over many years. That's the culture.

Structurally, the popularity of its existing games gives Supercell a fantastic data set for measuring whether a new game will last for months or years. The revenues from its three titles means the company doesn't have to chase short-term hits, and has the luxury to wait until its next evergreen game comes

along. The revenues also mean it can spend money on marketing the existing titles (Supercell was reported to be spending \$1 million per day promoting its games) and finding new players.

Timing has been crucial. "They entered the market at the perfect moment," Gardner says. "When they launched, you didn't need as much money to build and market a product."

Supercell is now in a strong position. "Longevity is at the absolute heart of these games," Lovell says. "It's always been the case in the games industry, the rate in which well-known franchises come out – FIFA, Call of Duty... But now we're seeing it's not another version of the game, it is literally the same game. I can predict right now what the top games of 2016 are going to be, because I'll just give you the top ten so far. The only other creative medium where you can do that is West End musicals."



At least one player
– in this case,
JNatsu – has
proposed through
Clash of Clans





ocus is not the things you do, it's the things you say no to," says Paananen.

And Supercell says no a lot, in different ways, at different times. Anyone can come up with an idea for a game and convince other Supercell employees to join their team. The best way to do this is by developing a prototype, which usually takes a week. From then on, the game lead stands up every Friday afternoon and tells the rest of the company how the game is progressing. Many games are killed at this stage. A few months later, the team will put out a "company playable", which every employee plays and gives feedback. Many games are killed at this stage. After this, the team prepares a date for a soft launch, in the Canadian app store (to allow games to keep a slightly lower profile). After launch, the team closely watches how the game progresses. Many are killed at this stage, most recently, Spooky Pop and Smash Land. They only lasted a few months in 2013. "It's not for everybody, and it's not for the faint-hearted," Louhento says.

"We don't feel bad about it, because it was our decision," adds Jonathan Dower, the lead developer on *Smash Land*. The game was popular, but it "didn't have the pull [to keep people playing] for years". He's now working on the next game; when WIRED visits he's about to give his first Fridayafternoon presentation, and start the whole six-month cycle again. Touko Tahkokallio, a game designer on *Boom Beach*, is "getting his team together and working on an idea". Louhento and Lappinen have already created a company playable for their new project.

Can they develop another *Clash* of *Clans*? "I'm not yet ready to say that Supercell has eliminated the hit business by making a game that continues for a long time," Lovell says. "But it's way more profitable than gambling on the next hit. So, yes, I'm worried they haven't got another hit. But nowhere near as worried as I am for somebody whose business model is fundamentally based around this."

"We as investors want things faster than is needed," Gardner says. "I think Supercell has a long, long way to go."

Much of the calm that radiates throughout Supercell comes from

Paananen. He puts people at ease. True to his promise as CEO, he gets out of the way. Ask five former investors to choose one word to describe him, and they all give the same reply: "Humble."

There is no secret to making wildly popular mobile games, but Supercell has a structure that maximises its chances. "Is it going to happen next year? I have no idea," Paananen says. "But will it happen in ten years? Yeah, I'm confident that it will happen. Like, we have all the time in the world."

Tom Cheshire (@chesh) is technology correspondent at Sky News

How Supercell succeeds

Three reasons why the gaming giant dominates mobile gaming

1

Focus on one platform

The company has chosen to develop for mobile, which allows reaching billions of users with just a small team.

2

Allow teambased freedom

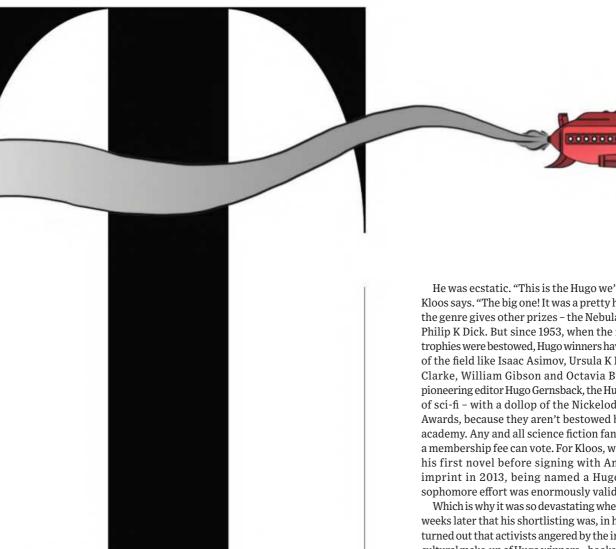
Supercell has a "small-cells" structure, with teams of seven working on their own projects. This is key to luring the best developers. 3

Keep iterating

The team continues to develop its games after they have been released, adding more features for longevity.







he year is 2108, and things aren't going so well for Team Humanity. Earth is so overcrowded that people live in hive-like concrete cubicles called Public Residence Clusters and subsist on reconstituted soy. Things aren't much better 30 light years away, in Earth's run-down Outer Colonies. No wonder the hero of Marko Kloos' first novel, Terms of *Enlistment*, joins the space-going military to escape those terrestrial slums. By Kloos' second book, Lines of Departure, his protagonist is half a decade into a career that includes vicious interstellar conflict with an indestructible alien species. Think Robert Heinlein's Starship Troopers with maybe a dash of James Cameron's Aliens.

On March 19, 2015, Kloos, a former non-commissioned officer in the German military who now lives in rural New Hampshire, sat down at his computer in his tiny study. Angles of Attack, the third book in his series, was a month away from release; he was on deadline with the fourth. But instead of writing, Kloos found himself staring at an email from the organisers of science fiction's pre-eminent awards: "We are very pleased to tell you that *Lines of Departure* is one of the 2015 Hugo finalists in the Best Novel category."

He was ecstatic. "This is the Hugo we're talking about," Kloos says. "The big one! It was a pretty happy time." Sure, the genre gives other prizes - the Nebula, the Tiptree, the Philip K Dick. But since 1953, when the first silver rocket trophies were bestowed, Hugo winners have included deities of the field like Isaac Asimov, Ursula K Le Guin, Arthur C Clarke, William Gibson and Octavia Butler. Named for pioneering editor Hugo Gernsback, the Hugos are the Oscars of sci-fi - with a dollop of the Nickelodeon Kids' Choice Awards, because they aren't bestowed by members of an academy. Any and all science fiction fans who care to pay a membership fee can vote. For Kloos, who self-published his first novel before signing with Amazon's 47North imprint in 2013, being named a Hugo finalist for his sophomore effort was enormously validating.

Which is why it was so devastating when he realised a few weeks later that his shortlisting was, in his eyes, a sham. It turned out that activists angered by the increasingly multicultural make-up of Hugo winners - books featuring women, gay and lesbian characters, and people and aliens of every colour - had gamed the voting system, mounting a campaign for slates of nominees made up mostly of white men. Kloos, who is white, says he was sickened to see his name listed. "I knew right away I was going to have to sit down and write an email and reject the nomination," Kloos says. To his publisher, whose authors had never gotten a Hugo nod, Kloos was blunt. "This is the kind of stink," he said, "that doesn't wash off."



It is the early 21st century, and things aren't going so well for Team Humanity. Back in April 2015, when the mainstream press first started reporting on the attempt to hijack the Hugos, few outside the field cared. The edging out of fanfavourite authors who were women and people of colour was unfortunate and ugly, but it seemed confined to one of literature's crummier neighbourhoods – nerd-on-nerd violence.

But like the sound of starship engines, the Hugos don't exist in a vacuum. "Gamergate" spawns rape threats aimed at women who have the temerity to offer opinions about video games. The leading representatives of mainstream political

parties build platforms around fear of Muslims and Planned Parenthood. A certain strain of comic book fan goes apoplectic when Captain America gets replaced with a black man and Thor gets replaced with a woman. (When Thor once got replaced by a frog, no one uttered a peep. Or a ribbit.) *Mad Max: Fury Road*, in which Charlize Theron seeks to rescue a bunch of women from sex slavery and Max is more of a sidekick, drove the so-called mens' rights movement into a froth.

It looks an awful lot like a counterrevolution – a push by once-powerful forces attempting to reclaim privileged status. Nowhere is this revanchism playing out more vividly than in the culturally potent literary subgenre of science fiction.

The three white men who led this movement broke no rules when they selected and promoted their Hugo nominees. They took advantage of a loophole in an arcane voting process that enables a relatively small number of voters to dominate. First a group calling itself the Sad Puppies posted a slate of suggested candidates to a well-trafficked blog (a slate that included women writers as well as men). Then, a day later, a more militant

'I love chaos. I wanted to leave a big, smoking hole where the Hugos were'

wing, the Rabid Puppies, posted another slate that captured most of the original writers and added several more – with a directive that people vote it without deviating, creating an unstoppable bloc. Now, all the various Puppies insist they're trying to expand, not reduce, diversity – at least as they define the word. They say the Hugos have gotten snobby and exclusionary. The Puppies hate the politicisation of a genre they love and want to return it to its roots: exploration of the unknown and two-fisted adventure.

Of course, like all fiction, science fiction is inherently political. Mary Shelley's *Frankenstein*, arguably the first sci-fi novel, was a monster story that explored the ethics of technological advance and the responsibilities of parenthood. Sci-fi uses a fantastical toolkit to take apart the here and now – from HG Wells's novella *The Time Machine* to Paolo Bacigalupi's *The Windup Girl*, a cautionary tale of climate change. So trying to crush diversity of authors, of characters, of stories, of themes in sci-fi crushes the whole point. Which is perhaps the main reason to worry about Puppygate: sci-fi that accommodates only one future, one kind of politics and one kind of person just isn't doing its job.

That's partially why so many authors with literary aspirations come sniffing around the genre so often. It lets them wrap ethical and cultural issues in highly readable plots. And now that movies are dominated by space and superheroes, television by dragons and zombies, books by plagues and ghosts, science fiction isn't a backwater any more. It's mainstream.

Over the summer, as the 73rd World Science Fiction Convention – where the Hugo winners are announced –

approached, the final balloting became a referendum not only on the future of the genre but on the future of the future. "It's one award," NK Jemisin, the fantasy writer and two-time Hugo nominee, tells WIRED, "but it's a symbol of a battle for the zeitgeist."

It's the year 1939, and things aren't going so well for the humans at the first World Science Fiction Convention, or Worldcon. About 200

at the first World Science Fiction Convention, or Worldcon. About 200 fans have gathered in Caravan Hall at the New York World's Fair and almost immediately start bickering. The bulk of the assembly suspects some members of a splinter group known as the Futurians – including pre-legendary Isaac Asimov and Frederik Pohl – of being communists plotting to disrupt the proceedings. Worldcon grandees bar them from entry. Isaac Asimov, characteristically, sneaks in.

THE BOOKS AND STORIES THAT SPARKED A CULTURE WAR

By Lexi Pandell



"The Water That Falls on You From Nowhere"

John Chu

After water begins raining down on liars, a gay man comes out to his traditional Chinese family.



Ann Leckie

The only survivor of a destroyed starship seeks revenge in a far-future society that can't see gender.





The Three-Body

Civin Liu

The first-ever Chinese nominee beat out the Puppies' slate.

Undeterred, the Futurians circulate a pamphlet that warns attendees of being "pounded into obedience by the controlling clique." The pamphlet continues, "It is for you to decide whether you shall bow before unfair tactics and endorse the carefully arranged plans of the Convention Committee. Beware of any crafty speeches or sly appeals. Be on your guard!"

The point is, sci-fi and fantasy fandom was born in struggle over who owned the genre. The Sad Puppies and the Rabid Puppies aren't even the first to campaign for the award. In 1987 the Church of Scientology successfully lobbied to get L Ron Hubbard's novel *Black Genesis* nominated for a Hugo. It finished sixth out of five nominees, defeated by "No Award".

The leaders of the Puppies movement are sci-fi authors. All are past Hugo nominees, though none of them has ever won. Larry Correia is a 40-year-old Utah accountant, former gun store owner and National Rifle Association lobbyist turned novelist. He created the Sad Puppies three years ago, after seeing an American Society for the Prevention of Cruelty to Animals ad featuring musician Sarah McLachlan and forlorn canines staring into the camera. "We did a joke based on that: that the leading cause of puppy-related sadness was boring message-fic winning awards," he says, laughing. Correia also explains that initially, in that first campaign, "our spokesman was a cartoon manatee named Wendell. Wendell doesn't speak English. You can see we kept this really super serious, right?"

But Correia had some serious complaints. He felt that the Hugos had become dominated by what internet conservatives call Social Justice Warriors, or SJWs for short, who value politics over plot. When Correia unleashed the Sad Puppies campaign for the second time, in 2014, two Hugo contenders really set his comrades off. One, a short story by John Chu called "The Water That Falls on You From Nowhere", depicts a gay man who decides to come out to his traditional Chinese family after water starts falling from the sky on anyone who tells a lie. And in Ann Leckie's debut novel *Ancillary Justice*, most of the characters in a far-future galactic empire do not see gender, which Leckie conveys by using only female pronouns.

Correia's Warbound lost to Leckie's novel at the 2014 Hugos. This year, the Puppies got his Monster Hunter Nemesis a nomination, but he turned it down. "I very specifically don't want this to be about me," he says, "and I didn't want them to be able to make it about me." Correia and Brad Torgersen, a 41-year-old chief warrant officer in the US Army Reserve who took over the third Sad Puppies campaign this year, says they're not racist or sexist or anti-gay. They just want sci-fi to be less preachy and upper-crusty and more fun. Torgersen calls his books blue-collar speculative fiction; on the phone from the Middle East, where he is currently deployed, Torgersen laments what he calls "the cognitive dissonance of people saying, 'No, the Hugos are about quality,' and then at the same time they're like: 'Ooh, we can vote for this author because they're gay,' or 'Ooh, we're going to vote for this author because they're not white."

Torgersen often notes in interviews that he's been married to an African-American woman for 21 years, so "I don't need some know-it-all to come lecture me about race stuff," he says. Torgersen says the Hugos are beset by identity politics – and are the poorer for it: "When people go on about how we're anti-diversity, I'm like: no. All we're saying is storytelling ought to come first."

But that's not all the Puppies are saying. At least, not the Rabid faction. Their leader is a self-described libertarian blogger named Theodore Beale who goes by the pen name Vox Day – loosely, "the Voice of God", though he says the meaning of the name is more complex. He's a 47-year-old former rocker (he wrote songs for Psykosonik) and is the son of a wealthy Minnesota entrepreneur and Republican leader currently in jail for tax evasion. Beale speaks five languages, he explains, and one of his children "is the youngest male published author in history." The book came out when the boy was six.

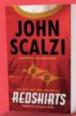




The Hundred Thousand Kingdoms

NK Jemisin

for her mother's



Redshirts

Star Trek is of dumb.



"If You Were My Love" Rachel Swirsky



Astronaut of Mars'

Mary Robinette Kowal

the Red Planet



Chicks Dia **Time Lords**

their love for Doctor Who.

Beale also says that he's not white. "I'm Native American. My great-grandfather rode with Pancho Villa, and I get to make that claim, according to the rules of SJW." When asked how much Native American blood he has, he says, "I'm not going to go into details, but I will say that it is so significant that even my kids qualify for tribal membership. I'm a mix. I mean, I'm also considered a Mexican. I have the genetic analysis."

Based on his voluminous writings, Beale - who writes fiction, edits for a small publisher called Castalia House and designs games - opposes racial diversity, homosexuality and women's suffrage. Speaking by phone from his home

in Northern Italy, Beale quibbles with that analysis. For example, he says he doesn't oppose all women's suffrage, just women voting in a representative democracy. The reason: "Women are very, very highly inclined to value security over liberty" and thus are "very, very easy to manipulate." He favours direct democracy - and, obviously, men.

Having a conversation with Beale feels sort of like walking around a room designed by MC Escher. It turns in on itself in unexpected and at times dizzying ways. A sampling: when WIRED asks him why he once called Jemisin, who is black, an "educated, but ignorant half-savage" on his blog, he says it wasn't because of her race. Then he launches into an explication of what he calls "new" genetic research, which he says he doesn't expect very many people to understand.

When it is suggested that he was intentionally baiting a person of colour with a term that has racial overtones, his answer sounds positively gleeful. "I'm calling her a half-savage because I know it's going to offend the crap out of her," Beale says. "She's going to run around screaming 'Racist! Racist!' for the next ten years." A beat, and then he adds: "I don't consider all black people to be half-savages. I mean, some people are. Here in Europe, for example, we have actual proper Africans, not African-Americans. This leads to problems, like people shitting on top of the closed toilets. They don't know how to use indoor plumbing, OK? This is not civilised behaviour."

Torgersen says he believes Vox Day is a character Beale plays. "It's performance art, like Andy Kaufman. He's Darth Vader breathing heavily into your phone. He wants people to be enraged and flipping out and tearing their hair and completely losing their minds. And he gets that every single time." Beale - whose slate got five of Castalia House's writers

> and editors, including himself, on this year's Hugo ballot - acknowledges his rogue reputation. "I love chaos," he says. "I wanted to leave a big, smoking hole where the Hugo Awards were. All this has ever been is a giant 'fuck you' one massive gesture of contempt."

'Science fiction is not the literature of the future. It's the literature of the present' It is... well, some vaguely medieval period in a land with teleportation and magicians called scriveners, and things aren't going so well for the brown-skinned, matriarchal warriors in the barony of Darr, one of many territories in the world of NK Jemisin's debut novel, The Hundred Thousand Kingdoms (first in a trilogy, of course). To obtain birth control, poorer people buy illegal, bootleg spells called sigils that last only a month, or they risk sterilisation or death by trying to apply sigils to themselves. The Darre people have also managed to enslave several of their gods. And the gods? They're furious.

Like Tolkien's Middle-earth, Jemisin's world is what's called in the trade a secondary world, "but it's not meant to emulate anything that looks like our world or any of our cultures," she says. And that, of course, is part of the point. When Jemisin was in elementary school in Mobile, Alabama, she noticed that no one in any of the stories in the sci-fi section of her local library looked like her. "I had picked up the fact that science fiction and fantasy was about white people," she says. So the description of the protagonist in Octavia Butler's novel Dawn hit Jemisin like a lightning bolt. "I remember the mention of her family name, and the fact that she'd married a Nigerian man and people's reactions to her," she says. "I suddenly had this 'Oh, my God, she's black' moment." Jemisin came by her confusion honestly: the cover of the 1987 edition featured a white woman with black hair. In later editions, the illustration was changed to a black woman.

Women and people of colour have always written science fiction – Butler, Le Guin, Anne McCaffrey, Samuel R Delany, Margaret Atwood and many more. They've made comic books and video games and movies too. But today these properties aren't alt-texts anymore. As science fiction has become mainstream, the genre has gotten more diverse. Major comic-book publishers are foregrounding women and people of colour. The casts of the new *Star Wars* movies have their diversity cranked to It's a Small World levels.

So you might be asking yourself: isn't there room for everybody under the science fiction tent? You guys over there can keep reading hard military sci-fi where the physics of deceleration from 0.5c is a plot point. And you guys over here can read about a transgendered person with dark skin and epicanthic folds pondering the existential implications of sex with an AI.

But here's the truth, as Jemisin has eloquently blogged: white male authors have long enjoyed unacknowledged privileges. Even today, their books are more likely to get published, more likely to be reviewed (usually by white men), and more likely to get those reviews in prominent, mainstream publications – even though, Jemisin says, the audience for sci-fi and fantasy books includes so many women and people of colour.

Jemisin recently published her sixth novel – *The Fifth Season* – which garnered her first-ever review, a rave, in the *New York Times* Sunday books section. The book explores themes of oppression that are not foreign to her; indeed, Jemisin has gone to battle with Beale. "He dances up to the line and tries carefully not to cross it," she says. "He simply says, 'This person is not human,' then opens his comments section and doesn't stop anyone when they start saying, 'We should run a train on that bitch.' This is the standard modus operandi for white supremacists who don't want to go to jail."

Despite all the bile sprayed at her (the "train" threat is a euphemism for gang rape), Jemisin still believes that her chosen genre has a lofty purpose.

'Nerd culture brings everyone together. People don't care what you look like' "Science fiction isn't the literature of the future," she says. "It's the literature of the present, viewing the future as allegory."

Yet amid the Puppies debate, something else is going on, too: in a genre defined by curiosity, by the question "What if?" and by yearning for a sense of wonder, some fans acknowledge that modern science fiction can feel infected with a certain academic torpor – if not outright self-indulgence. As one Sad Puppy supporter at this summer's Worldcon grumbled, "Just because you had a dream doesn't mean we all want to read it," he said. "Just because you have an MFA and write a story, you may win a Hugo, but don't kid yourself: some of this stuff is unreadable."

Annie Bellet wouldn't go that far, but she does admire many of the authors the Puppies championed. The 34-year-old writer of self-published urban fantasy novels had a short story, "Goodnight Stars", on both the Sad and Rabid Puppies slates and received her first Hugo nomination this year. Still, she – like Kloos – took her name out of the running. "I love the Hugo Awards," Bellet says in an emotional interview in the convention hall. "To be nominated was awesome. But I'm a writer. That's what I want my public face to be. I don't want people to think of me as some political figure or some ball in a political game."

For Bellet, the Sad Puppies aren't abstractions – they're people she actually knows. She thinks Correia is a "great guy" and loves his seven-book *Monster Hunter* series. And she once considered Torgersen an ally. They met in a writers' workshop. "We came up as baby writers together. We were friends – and I'm using the past tense," she says, wiping away tears. "He's hurt a lot of people."

Blonde-haired, fair-skinned, and "covered in tattoos," as she puts it, Bellet is from Portland, Oregon. "I'm adopted, and I have a sister who is black, a sister who's Vietnamese. My mom is a lesbian. I grew up in a liberal, inclusive environment. I broke a lot of noses after hearing the N-word growing up, trying to defend my sister. So I don't understand this white persecution narrative."

Bellet says she thinks Beale "rode" Correia and Torgersen "like ponies. I told Brad that. He said, 'Just because we're on the freeway in different cars heading the same direction doesn't mean we're together.' I said, 'Dude, you're in the same car, and Vox Day is driving.' He doesn't get it. It makes me so sad."

She doesn't think Beale even read her short story. Bellet was on the Sad Puppies slate her one-time friends had promulgated, which he mostly copied. "I'm everything Vox Day doesn't like – which I consider a badge of honour," she tells me. "I'm a queer female writing about shape-shifters – that fantasy 'crap' that's not 'real' science fiction." Here's the thing she thinks Beale doesn't grasp, she says: "Nerd culture brings everybody together. People don't care what you look like. If you want to be a black Khaleesi, go for it!"

It is August 2015, and things are looking up for Team Humanity. Or are they? A record 11,700-plus people have bought memberships to the 73rd World Science Fiction Convention in Spokane, Washington, where the Hugo winners are soon to be announced. A record number have also forked over dues of at least \$40 (£26) in time to be allowed to vote, and almost 6,000 cast ballots, 65 per cent more than ever before.

But are the new voters Puppies? Or are they, in the words of *Game of Thrones* author George RR Martin, "gathering to defend the integrity of the Hugos"? Just before 8pm on August 22, in a vast auditorium packed with "trufans" dressed in wizard garb, corsets, chain mail and the like, one question is on most attendee's minds: will the Puppies prevail?

The evening begins with an appearance by a fan cosplaying as the Grim Reaper, and that turns out to be an omen for the Puppies. By evening's end, not a single Puppy-endorsed candidate takes home a rocket. In the five categories that had only Puppy-provided nominees on the ballot – Best Novella, Best Short Story, Best Related Work and Best Editors for Short and Long Form – voters choose "No Award".

Earlier, Beale explained to WIRED that his plan was a "Xanatos gambit" – "that's where you set it up so that no matter what your enemy does, he loses and you win." No surprise then, that in an email he sends after the awards ceremony, Beale is crowing. "The scorched-earth strategy being pursued by the SJWs in science fiction is evidence that we hold the initiative and we are winning," he writes. The number of major categories in which no awards are given "demonstrates the extent to which science fiction has been politicised and degraded by their far left politics."

But even as Beale vows to renew the fight, John Scalzi, a novelist and three-time Hugo winner who has been among Beale's most outspoken opponents, says the prominence of writers like Jemisin proves the war is already over. "She stands on the shoulders of every other woman and minority and gay and lesbian and trans- or bisexual folk who had to put up with shit before," he says. "She and lots of other people are now in a position where they can firmly plant their feet and say, 'This is bullshit,' and have a large number of people go, 'You're absolutely right.""

Which brings us back, in a roundabout way, to Martin. He has attended almost every Worldcon since 1971 and has won four Hugos and lost 15, not counting any related to the HBO show. So Martin says he can say with utter sincerity that it is an honour merely to be nominated – not because the Hugo is a hoity-toity accolade bestowed by Ivy Leaguers, as the Puppies charge, but because of the calibre of past winners, men and women alike.

Martin, the son of a longshoreman, rejects the idea that anyone has been excluded from the Hugos for being too lowbrow or politically incorrect. But, he says, it's not a popularity contest, either. "The reward for popularity is popularity! It's truckloads of money! Do you need the trophy, too?" he asks. "Can't the trophy go to the guy who sells 5,000 copies but is doing something innovative?" Of course, that's easy for someone of Martin's stature – and success – to say. But it's hard to argue with his lament about the hateful discourse and the name-calling that the Puppy-scuffle has prompted. At one point earlier this year, Martin was so despairing that he blogged that the Hugos had been broken. "I am not sure they can ever be repaired," he wrote.

By the time he shows up in Spokane, however, Martin is more optimistic. Sanguine enough, in fact, to plan a Hugo Losers Party, a tradition he'd started back in 1976 but then let fall into other hands. Martin prints up invites – "Losers Welcome. Winners Will Be Mocked. No Assholes!" – hires a band and a caterer, and rents a 1,000m² historic mansion. The party starts right after the Hugo ceremony ends, and winners who show up are required to don rubber coneheads. Losers get magic markers to write on the cones.

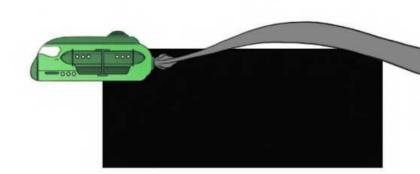
After midnight, Martin takes to a balcony to announce that, for the first time, he will bestow his own awards – dubbed the Alfies in honour of Alfred Bester, whose book *The Demolished Man* won Best Novel at the first-ever Hugos in 1953. "This year all of us were losers," Martin says, explaining that the Alfies, made at Martin's expense from streamlined 1950s hood ornaments, are his attempt to take a little of the sting off.

Before the Losers Party hits full swing, Worldcon releases data that allows a look at a parallel universe where the Puppies hadn't intervened. That lets Martin give trophies to the people who would have been on the ballot if not for all the barking, as well as some extra winners decided "by committee, and that committee is me," Martin says. Sci-fi writer Eric Flint gets an Alfie for his "eloquence and rationality" in blog posts about the Puppy kerfuffle. Legendary author Robert Silverberg, who has attended every Worldcon since 1953, receives an Alfie just for being himself.

The biggest cheers, though, break out when Martin honours Annie Bellet and Marko Kloos. The new data shows Bellet would likely have been on the ballot even without the Puppy slates; the Alfie clearly stuns her. In her acceptance speech she says she wants the Hugos to "be about the fiction. And that was important enough to me to give one up."

By turning down his Puppy-powered nomination, Kloos had made room on the ballot for the winner, Cixin Liu's *The Three-Body Problem*. Kloos tells me he was thrilled to have played even a small part in honouring the novel, and earlier in the evening he'd posed for photos with the book's translator. Now, standing on the balcony with Martin, Kloos grips his hood ornament and grins broadly. "I may get nominated again," he tells the party goers. "But knowing why I got this and who gave it to me – tonight, this beats the shit out of that rocket."

Amy Wallace writes for Los Angeles and GQ and is co-author, with Ed Catmull, of Creativity, Inc.



OVERHEARD AT WIRED THIS MONTH

"It's like a magazine within a magazine. Think Inception, or the Funday Times" - the concept behind our new R&D section. "I love a good narenthesis. It's like Shakespeare's wittiest asides. but in my copy." "My God, I'm a genius. No, wait. I'm not." (Five minutes pass) "OK, ves, I am a genius," "Can we get a better shot of a volcano? More exciting... More. FFFWWSSSHHH!"

"Stories about batteries - people I OVF them" "The return of the rounded typeface! No, it's not weird just colour it blue." "It's definitely for review purposes only. Absolutely no enjoyment permitted" - some serious journalistic restraint in the face of receiving the entire range of LEGO Dimensions playsets (including Ghostbusters and Back to the Future).



ACCIDENTAL **THEMES** THIS MONTH WIRED's art

department worked with five different illustrators for this month's Ideas Bank. When the first round of sketches came in. each one included a profile of a person or an aeroplane. Unprompted. So, any thoughts on the deeper symbolism of aeroplanes and heads in profile?



SKETCHING **FOR PIXAR** THIS MONTH Creating this

month's cover required running concepts past Pixar - but their main concern? That we get the scale of Arlo the Apatosaurus exactly right. He's 5.7m tall, in case you wondered.

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THE WIRED INDEX

999kb

Size of the largest bitcoin transaction ever made, on July 7, 2015. It was carried out by Chinese bitcoin miner F2Pool, to restart the crypto-currency network after it had been slowed down by an external attack



The number of times that Norwegian police officers fired their guns in the line of duty in 2014, according to an internal review

31

The number of female chess grandmasters. A dearth of female chess coaches and the meagreness of prizes paid in all-women chess tournaments are two theories put forward to explain the disparity with male grandmasters

92%

Apple's share of the smartphone market's profit in Q2 2015, according to Canaccord analyst Mike Walkley 20%

Apple's share of the smartphone market throughout the same quarter, according to Mike Walkley

18,520

The number of flash stock-market crashes to occur between 2006 and 2013, most caused by automated trading systems, according to nature.com. Fortunately, the majority lasted less than 1.5 seconds and had little impact

625,000

Number of hybrid vehicles recalled by Toyota due to a software malfunction. The glitch could shut the car down suddenly while being driven

\$29.34

The average Uber driver earnings per trip in New York City, according to payment company Sherpashare

\$28.62

The average Lyft driver earnings per trip in New York City, according to Sherpashare

Boxes of cookies sold by 13-year-old Oklahoman Girl Scout Katie Francis in 2015. It's an all-time record

21,477

The previous cookie-selling record, also set by Katie Francis the previous year

9,500

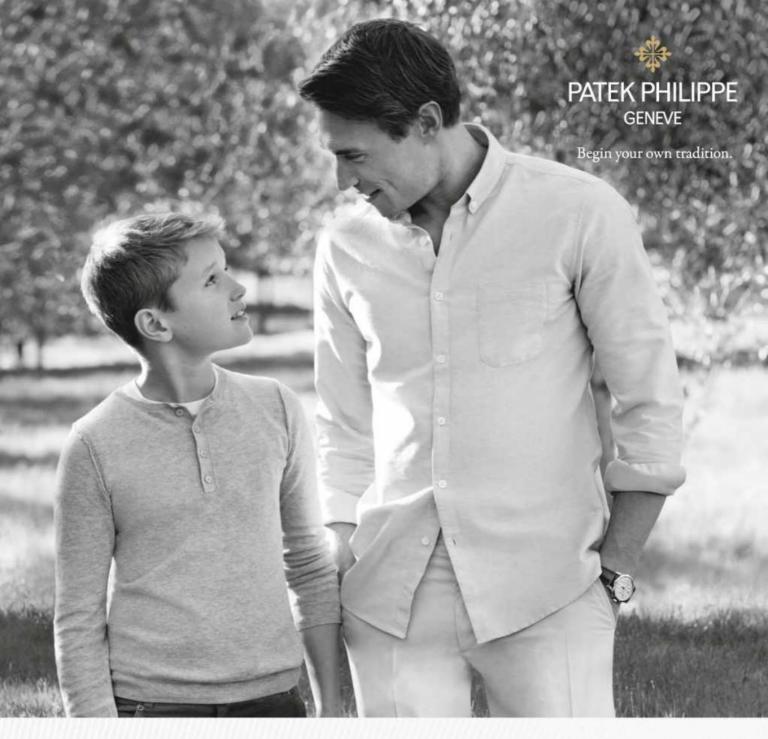
The estimated number of people in London who die each year due to long-term exposure to air to pollution, according to a study carried out by King's College researchers





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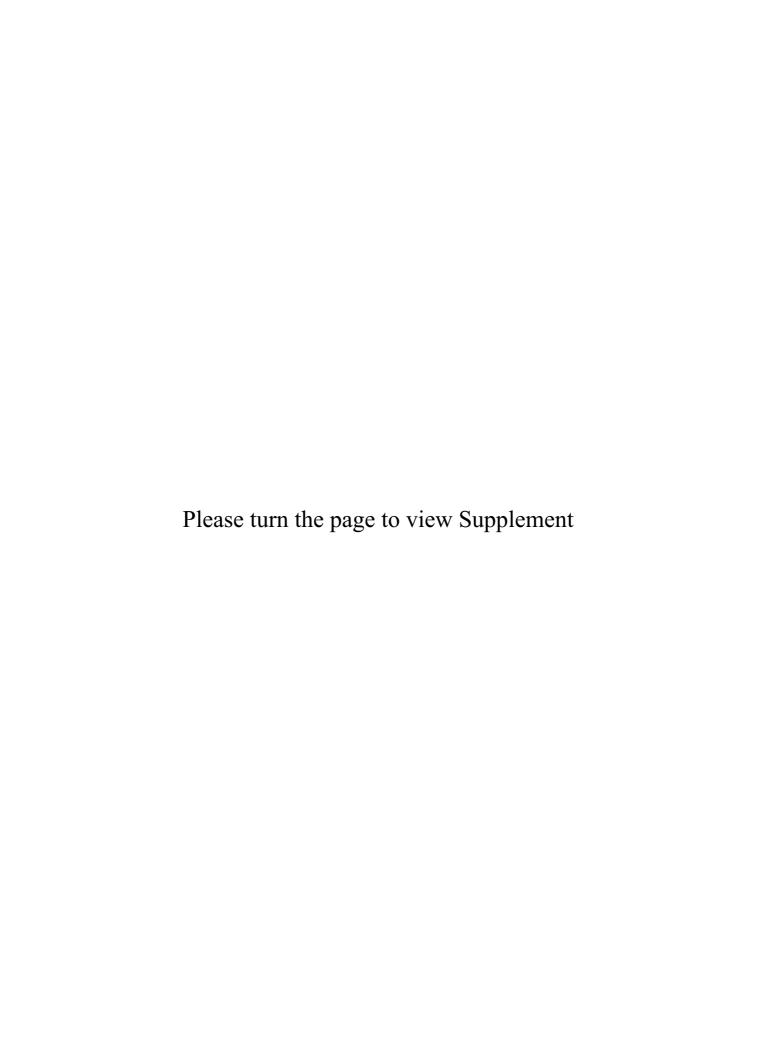


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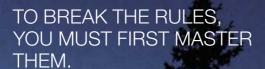
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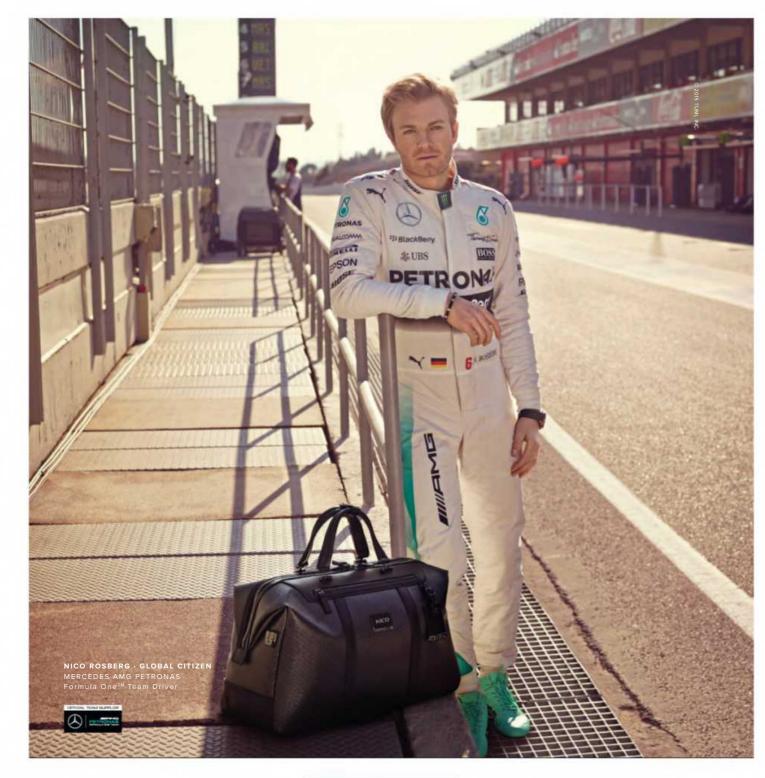
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elcome to the third annual celebration of the finer things in WIRED's world. This year, our take on the intersection between luxury and innovation is grander than ever: on p10, Alex Doak gets behind the wheel of some unflinchingly VIP vehicles, from a British-made electric supercar aiming to leave Tesla for dust to probably the world's only executive tank. Meanwhile, on p26, Jonathan Bell explores how leading architectural practices are bringing a fresh perspective to the production of one of the oldest commodities known to man, in his report on three wineries that double as sculptural statements.

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Advertising and promotions manager **Max Mirams** Senior account manager **Elaine Saunders** Otherwise, should you wish to indulge a passion for fashion, Rachel Arthur has engaged the pioneers finding new and meaningful ways to weave technology into tomorrow's haute couture on p20. We have also decided to integrate WIRED's Sound & Vision supplement into Desired for the first time, hence you may notice our extended Fetish section is almost entirely dedicated to audiovisual hardware designed to push the boundaries of how we are entertained, even if it's sometimes by the smallest of margins. After all, luxury is in the detail. Henry Farrar-Hockley

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It has been produced
using wood sourced from
sustainably managed
forests and elemental or
total chlorine-free bleached
pulp. The producing mills
have third-party-certified
management systems in
place, applying standards
such as ISO 9001 and ISO
14001. This magazine can be
recycled aither through your
kerbside collection or at a
local recycling point. Log
on to www.recyclenow.com
and enter your postcode
to find your nearest sites.

-





Six executive vehicles that break boundaries and preconceptions. Words by Alex Doak

A high-end custom garage brand, Auto Fabrica is based out of an industrial unit in Southend-on-Sea. The Type 6 is one of four Yamaha XS650 bikes rescued from a farm in Cornwall and given a radical overhaul. The engine has been rebuilt with 0.5 oversize
pistons, and the
frame modified
by lowering the
headstock 5cm

back slightly. To create its scalloped profile, the tank and seat base have been crafted as a single form, using handrolled 2.5mm aluminium. autofabrica.com

SPEC

Price £42,000 Donor bike Yamaha XS650 1978 Engine 650cc
Power 55bhp
Weight 170kg
Max speed
Untested
Suspension Hagon
rear shocks,

BAC Mono Marine Edition

A firm WIRED favourite, with its 2.5-litre mountune engine and street-legal supercar spec, BAC's Britishmade racer, the Mono, has been re-engineered as a superlative ocean-going

runaround for the billionaire set. The superlow profile isn't just about racing lines – it's designed for easy storage aboard mega yachts. It ships with a bespoke carbon-fibre crane arm and integrated lifting points across its chassis, so you can get your ride dockside in a matter of minutes. Further aquatic nods for the Marine Edition include the option to

customise it inside and out to match your boat's décor, and the car's components and paint being anti-corrosive as standard, to prevent saltwater damage. bac-mono.com

SPEC

Price £500,000
Acceleration
0-100kph in under
three seconds
Top speed 274kph
Weight 580kg
Gearbox
Hewland FTR





Zeppelin Wireless. Next level audio performance.

Bowers & Wilkins



SPEC

Price €tbc
Body Full
composite
airframe
Engine Turbomeca
1,100shp Arrano
engine
Cruise speed
160 knots
Range 833km
with 20-minute
reserve

Consumerfocused flight systems include Garmin 3000based avionics and single-lever FADEC engine control



CIRRUS VISION SF50

The Vision SF50 jet arguably creates a whole new aviation category with the so-called personal jet, designed to be flown by the owner as opposed to a professional pilot. Mounted on a seamless monocoque carbon fibre

fuselage, the futuristic-looking piggyback engine and V-tail design aren't just for show: both are novel solutions to reducing cabin noise. Even cooler – and reassuring to boot – is the proprietary Cirrus Airframe Parachute System, a rocket-

deployed, 19.8m canopy that allows the craft to descend softly during emergencies. It's a technology which can already claim to have saved more than 100 lives via the company's SR20 and SR22 prop planes. cirrusaircraft.com

SPEC

Price \$1.96 million
Body Carbon fibre
Maximum ramp
weight 2,740kg
Engine Williams
International
FJ33-5A
Thrust 8,007N
Wingspan 11.67m
Length 9.42m
Max cruise 300kts
Range 2,037km
Capacity Up to
five adults and
two children





Price £250,000
Acceleration
0-100kph in less
than 4.5 secs
Top speed 250kph
Batteries 10,000cycle lithium
titanate
Range Up to 402km
Charge time 45
mins/50kW; ten
mins fast charge

LIGHTNING GT

Attempting to bring some of the exclusivity back to the British carmaking scene – while capitalising on the fledgling performance-electric sector (something Tesla has monopolised up to now) is lain

Sanderson's
Lightning brand,
whose two-seater
grand tourer is
finally set to land
in 2016. Eighty
per cent of its
components are
sourced from
these shores –
including the
MAGTEC drive

train – and its fast-charging lithium titanate cells promise a range of more than 400km. The GT's gorgeous, slightly retro stylings and supercar performance should appeal

immediately to those seeking zero-emission thrills. And for the more practically minded, an SUV with a range extender is also in the works. lightningcar company.com



Serious About Coffee?



Real Italian coffee at home, at the touch of a button

The Eletta bean to cup machine from De'Longhi serves your coffee shop favourites by grinding fresh beans and frothing fresh milk for the perfect taste. With self-cleaning and personalisation features, Eletta is your perfect Barista at home, ready to serve you real Italian coffee at the touch of a button.

Discover more at: www.delonghi.com/seriousaboutcoffee





Download our FREE Coffee Expert App, available for download on the App Store and Google Play At the opposite end of the emissions spectrum to the Lightning GT is Howe and Howe Technologies' diesel-gulping "luxury super tank". Anyone who's witnessed the Discovery Channel series Black Ops Brothers will be familiar with the Howe siblings' modus operandi of handcrafting outrageous tracked vehicles. But the EV2 is their first foray into luxury, modifying a US military concept with a leatherupholstered interior and slick, Batmobileesque exterior.

The Bruce Wayne comparisons don't end there. It is genuinely, intimidatingly quick, flying off the line and nonchalantly tackling steep climbs – inclines upon which any other commercially available 4 x 4 would flounder.

SPEC

Base price \$295,000 Body **Sealed** and flotational aerospacealuminium hull Weight 3,629kg Engine 6.6L Duramax diesel Power 600hp Max speed 100kph Rate of climb 75 per cent incline Range 483km Suspension 30cm travel





FASHION

FUTURE FABRICATION

Advances in material science and smart textiles are setting the agenda for the next wave of wearable technologies. But are luxury brands paying attention? Words by **Rachel Arthur**

second world war, Salvatore Ferragamo experimented with fashioning footwear out of cork and raffia. In 1958 there was the invention of Lycra. Even those crease-resistant or moisture-wicking shirts we wear were once considered true technological advancements. But fashion never stays still – from wearable tech to engineered materials, designers continue to innovate.

Fabric innovation isn't a new concept.

In the face of leather rations during the

Berluti – a bootmaker-turnedmenswear *maison* – has released new hybrid fabrics including a cashmere and fine leather weave that resembles tweed, yet is fully washable. Issey Miyake, a Japanese designer famous for his pleats, has introduced a technique called 3D Steam Stretch that shrinks fabric into a pattern of rigid, three-dimensional forms programmed by computer. And Ralph Lauren launched its PoloTech Shirt at the US Open Tennis Championships in 2014, featuring a conductive silver-coated thread that monitors heart rate, breathing and steps taken. Devised in collaboration with Canadian firm OMsignal (which developed the technology), the

Right: Designs from Iris van Herpen's Radiation Invasion collection represent the amount of digital information we are subjected to daily





Below: The
Unseen's calfskin
backpack responds
to air-pressure
fluctuations.
When air hits the
material, coloured
markings appear,
returning to black
when indoors



Left: Taken from Iris van Herpen's Capriole collection, the "snake dress" was designed to evoke the mental state of a parachute jumper before they leap form-fitting athletic top finally went on sale at this year's tournament for \$295 (£190), together with its own iOS app.

Earlier this year, Google's Project Jacquard, together with Levi Strauss & Co, embedded communications in clothing – specifically a conductive yarn woven into its denim and accompanied by a small sensor to enable touch interactivity through the fabric itself. It will be available to buy later next year.

Ivan Poupyrev, technical programme lead at Google's Advanced Technology and Products (ATAP) group, suggests using the touch panels to call an Uber, silence your phone or take a selfie. "Not having a phone is a luxury, but it's a luxury none of us can afford in order to be functional in modern society," he says. "We're hoping to unload some of those [tasks] and make them accessible through easy and simple interactions."

Project Jacquard first tested the idea with a Savile Row tailor: "Taking it from a one-dimensional yarn, to a two-dimensional textile, to a three-dimensional

shape made by an artisan in a top location like Savile Row is proof that our project is viable," says Poupyrev. He's taken that sample – a jacket with the touch-sensitive section on the sleeve – to high-fashion brands in order to demonstrate Jacquard's capabilities and build future partnerships.

Jacquard's invisibility is at the heart of what Poupyrev is trying to achieve: tech-enabled yet unobtrusive, so the result still looks like a garment. This is something Amanda Parkes, CTO at fashion incubator Manufacture NY, agrees with. "Clothing is the language of desire, expression and identity," she says. "Any technology embedded in clothes has to enable that." Changing the colour of garments will be one way of doing so. For instance, researchers at Fudan University in Shanghai have collaborated with UCLA to create a weavable fibre made from polymer light-emitting electrochemical cells that glow and transform shades.

The Unseen, a London-based company fusing science with design, is also experimenting with colour. It launched its first collection, now stocked at Selfridges, at London Fashion Week in September 2015. The 13-piece line is a high-end but more wearable version of its earlier coded couture sculptures. There's a necklace that changes colour with body heat, an alligator shoulder bag that reflects the changing seasons and a backpack that shifts through a range of hues when wind blows across it. None of this is new technology - thermochromic garments have existed for decades it has just been applied in a fresh way.

Clothes that change shape are another growth area. Although Hussein Chalayan presented a vision of this with his robotic dresses in 2007, dynamic textiles that shift in form and silhouette are likely still five to ten years away. Reconfiguring the molecular structure of fabric to achieve this is something Joanna Berzowska, head of electronic textiles at OMsignal, is researching. She references experimenting with Nitinol, a programmable shape-memory alloy that can be woven into textiles.

Dutch designer Pauline van Dongen, who uses solar cells, phototropes and printed electronics in her work, believes there's great opportunity in making clothing more intelligent. "It's about being responsive and able to change – more tightly woven at one point and more open at another," she

says. She's exploring structural flexibilities through 3D printing; engineering the material pixel by pixel.

Iris van Herpen, also based in the Netherlands, has long used 3D printing to create intensely intricate sculptural forms. That technology is gradually becoming more comfortable, and thus wearable, which, she says, will make it attractive to major fashion houses. It's also a development that could help innovations scale, given manufacturing restrictions are otherwise a barrier for tech-enabled fabric innovation. Google's Project Jacquard isn't new in concept, for instance, but the way it will use existing machinery and processes is. Few are yet doing the same.

"A lot of tech you see on the catwalk works well, but they're not cost-effective to be made at scale," says Berzowska. "The kind of tolerances, attention to detail and quality assurance that has to be in place for a smart shirt is exponentially greater than even the most expensive luxury shirt."

While this is being worked out, it's one-offs that luxury consumers will continue to pine after. Scarcity feeds desire. As Parkes suggests: "Science is the ultimate luxury: it takes a lot of time, it's rarely done well and it's expensive."



Above: Issey Miyake's Omoiiro Series stole, which uses 3D Stretch Seam fabric to create a threedimensional form



HOPTROFF NO. 9

Richard Hoptroff caught the world's attention in 2013 with his atomic pocket watch. His range of smartwatches, inspired by the work of British horologist George Daniels, are fuelled by Bluetooth, which helps to discreetly convey a range of data, from the direction of Mecca to the latest football score. This model is a window on the stock market: at the end of a flow of numbers that snake across the lower half of the dial is a scale from -10 to +10 that displays the percentage share price change since the last close of trading. It looks complicated, but the watch syncs with your phone incredibly easily and, so long as you use the right ticker symbols on the accompanying app, it picks up the data and broadcasts it in seconds. That it resembles a classic watch makes the subterfuge even easier, although the analogue display means it can only track one market or share price at a time. 6/10 £4,000 hoptroff.com

HOW WE TESTED

As each of the watches on test is smart in its own specific way, WIRED focused on user interface, how they look and feel on the wrist, accuracy, build quality and – crucially – how their battery lives measure up with use.

SPEC

Movement
Hoptroff No. 9
Features
Switchable
left-handed
configuration;
perpetual
calendar; lowpower mode
Compatibility
Android; iOS
Battery life Two
to five years

MONTBLANC TIMEWALKER > URBAN SPEED E-STRAP

Given the simplicity of this design the oblong smart display fits directly on to the strap rather than the watch itself - this should have been the easiest timepiece on test to operate. However, after two days of toggling Bluetooth on and off in vain, WIRED had to seek the advice of a Montblanc engineer who duly explained that the device needed to be reset. After that, it synced in 30 seconds. The interface is straightforward and intuitive, and unlike the other watches on test provides email and text alerts along with basic music controls. All of the notifications were highly legible in snite of the diminutive canacitive 2.3cm monochrome OLED screen. The vibrate function felt surprisingly positive as well. Although the manner in which it is worn on the underside of the wrist means that it can remain connected yet unobtrusive, it felt uncomfortable. The exercise element also couldn't differentiate between cycling and walking, leading to inaccurate activity tracking. Currently, Montblanc's e-Strap is only sold along with the mechanical TimeWalker Urban Speed collection, but there are plans to retail it for use with any watch that features a 14.2mm-wide bracelet. 6/10 From £2,335 montblanc.com



Montblanc's e-Strap adds new functionality to a mechanical timepiece – such as being able to locate your watch within 30 metres via the smartphone app, or vice-versa. It is charged via micro USB and the case is rubberised steel.

SPEC

Movement
Calibre MB 25.07
(TimeWalker
Urban Speed)
Features Find My
Phone; haptic
vibration; remote
camera trigger
Compatibility
Android/iOS
Battery life Five
days (e-Strap)

DIALLED IN

The first wave of so-called 'horological' smartwatches have finally clocked in, but do they tick all the right boxes?



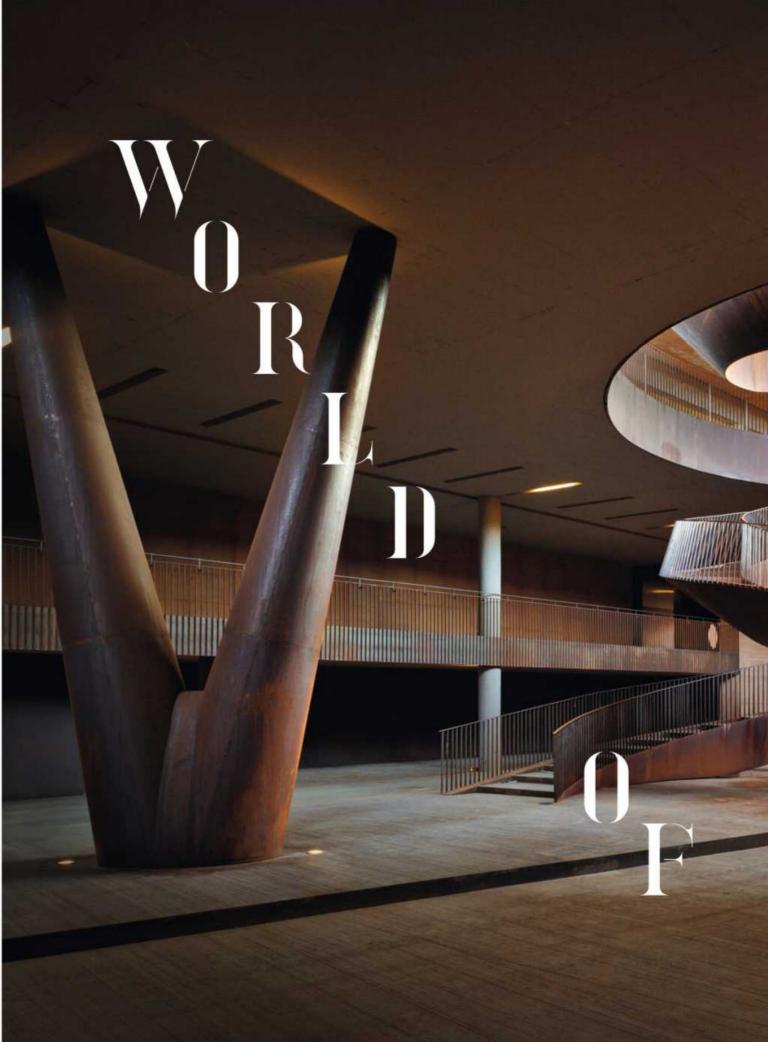
< FRÉDÉRIQUE CONSTANT HOROLOGICAL SMARTWATCH

Billing itself as the first truly horological smartwatch, Frédérique Constant has chosen to focus its functionality on activity tracking. Through the *MotionX* app, your daily activity and sleep cycles are tracked and backed up. Rather than using an LCD readout, the information is relayed to the wearer via the analogue subdial at the six oʻclock position. Aside from a few teething problems in getting the watch to communicate with an iPhone, once connected it was easy to use – the settings are simple to adjust and the phone was quick to pick up activity data from the watch. Getting the alarm to work via the Sleeptracker function was near impossible – WIRED admitted defeat after waking up late for two days running. The Horological Smartwatch's major USP is that, like the Hoptroff, it looks like a conventional wristwatch. With its leather strap, steel case and Roman numerals, it has all the design codes of a classic timepiece, right down to its convex sapphire glass. **7/10** £870 frederiqueconstant.com

SPEC

Movement MMT-285 Connected Features Water resistant to 5ATM Compatibility Android; iOS Battery life 25 months WORDS: LAURA MCCREDDIE. PHOTOGRAPHY: STEPHEN LENTHALL; DAVE LIDWELL





A host of unique buildings are rising from the world's vineyards,

boasting architecture that reflects the quality of their wines

Words by Jonathan Bell

WINERIES ARE PROVEN EARLY ADOPTERS of a contemporary architectural approach driven by the desire to build structures capable of garnering global recognition. Thanks to involving high-profile architects and wide-open briefs, a host of innovative and striking constructions are rising up among the world's gently undulating vineyards. With cascades of tumbling forms and sleek, sculptural statements allowing winemakers to increase their cultural capital, these buildings threaten to eclipse the art gallery as the ultimate place for architectural expression. Here are three recent projects that inspire "architours" which go beyond merely tasting the wines crafted within them.

Previous spread: Antinori nel Chianti's exterior staircase takes visitors to its cellar



ANTINORI NEL CHIANTI CLASSICO, FLORENCE, ITALY (2012)

In San Casciano in Val di Pesa, set among the vines that bring us Chianti Classico, sits a radical new structure by Marco Casamonti and his studio Archea Associati. The winery is completely integrated into the surrounding landscape, reshaping the contours of the land and incorporating a run of vines across its buried roof. Where the winery does break cover, it reveals itself in sculptural COR-TEN steel with reddish, pre-rusted forms that appear to have burst out of the soil. Ageing barrels are stored deep in terracotta brick vaults with parabolic roofs, and the recurrent theme of the building is a circular form that can be found punching its way through the structure. As well as storage and sales, there's also a museum, shop, offices and – of course – a tasting room, complete with covered terraces and walkways. The whole complex cost around &85 million (&60m), yet is largely concealed beneath the shallow slopes of the vineyard, reached by a winding access road that plunges into the earth through deep, canyon-like walls. Archea's design for Antinori evokes the spiritual and mystical side of winemaking, a temple of creation intended for veneration and wonder. *antinorichianticlassico.it*





Below:

The building's northern façade allows daylight to filter in during the day and becomes translucent at night





MEDHURST WINERY, VICTORIA, AUSTRALIA (2012)

Folk Architects' first foray into the building element of winemaking came in the form of this winery in Australia's celebrated Yarra Valley. Even more admirably, this small-batch operation was founders Tim Wilson and Christie Petsinis's first project. The duo's Melbourne-based practice used Medhurst to showcase their skills and the studio's philosophy. The building's location offers spectacular views to the Warramate forest, a landscape that's preserved as much as possible by keeping the new building long, low and intentionally separated from nature. Folk placed an emphasis on sustainable design (the vast roof can bring in 500,000 litres of rainwater every year, all of which is filtered and then used in the wine-production process). The building is unashamedly juxtaposed with the landscape, with thick slabs of concrete stalking across the hill, but it's also about engaging visitors with the process of winemaking. Inside, it's strictly about function, although the generous scale and careful attention to detail encourages visitors to stop by and see the production processes before indulging their tastes in the adjacent Cellar Door for direct sales. *medhurstwines.com.au*



GRAPE VARIETIES: Chardonnay, Sauvignon Blanc, Pinot Noir, Cabernet Sauvignon, Shiraz SIGNATURE WINE: 2013 Pinot Noir (A\$38 medhurstwines.com.au)



The winery has a transparent, stretched fabric roof that allows for natural sunlight to permeate without the need for artificial lighting



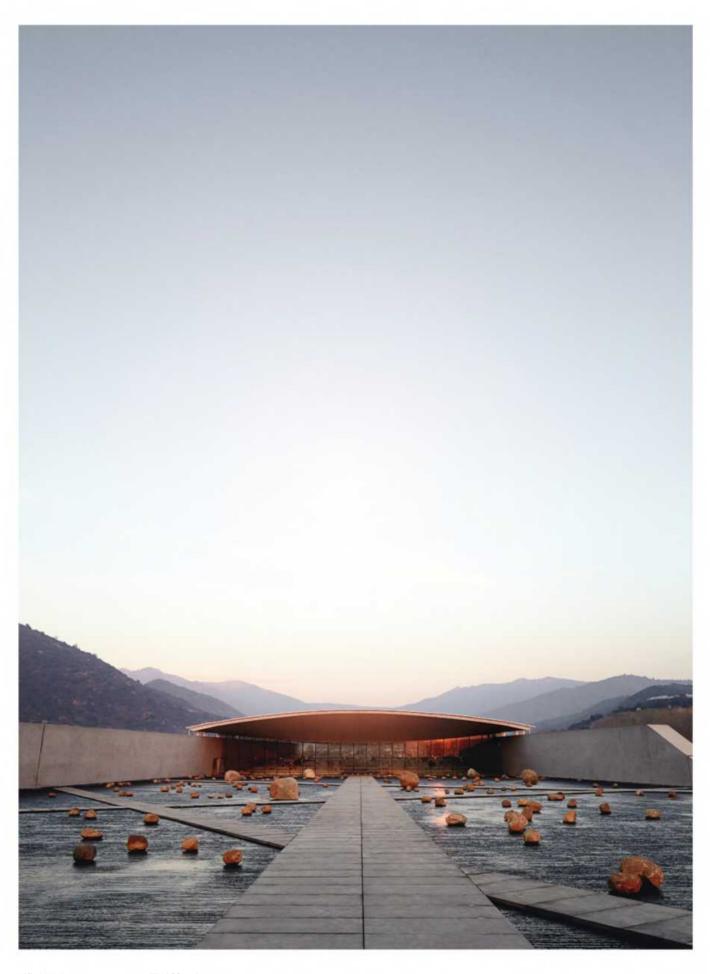
VIÑA VIK, MILLAHUE, CHILE (2014)

The VIK winery lies in the heart of the Chilean wine country that runs north-south through the valleys south of Santiago. Mindful of the blossoming association between wine and design, the owners ran a competition way back in 2006. The winner was Smiljan Radic, the Chilean architect best known for his pebble-like Serpentine Gallery Pavilion in London, and a clutch of elegantly prosaic private houses in his home country. "I had never built a winery before", he recalls. "It was a new and unknown theme." The result, created with his partner Marcela Correa, is a science-fiction landscape of stone and water, with an entranceway defined by a vast, shallow pool strewn with boulders of various sizes and criss-crossed by narrow pathways. This leads into the main storage and fermentation area, kept cool by the fabric roof, water and the cavernous Millahue Valley. Radic describes his approach as "unusual", especially given his lack of experience in the field, but emphasises that everything has been approached with "extreme rationality", despite the elaborate and dramatic installation. The vineyard, founded by Alexander and Carrie Vik, also serves as a retreat and dining destination. *vik.cl*





PHOTOGRAPHY: CRISTOBAL PALMA



Viña VIK also serves as an-art filled 22-suite retreat and spa perched on a hilltop





LEICA ULTRAVID 8x32 EDITION ZAGATO

These binoculars have a tactile textured surface achieved by milling the aluminium chassis with hundreds of grooves. The fluoride lenses are recessed behind matching contrastred anodised rings. As for the glass, the 8x magnification affords an ultrawide 135-metre field of view at 1,000 metres. Each of the 32mm-diameter lenses also benefits from a water- and dirt-repelling AquaDura coating. £2,465 leica-camera.com

E



The Edition Zagato binoculars are produced in a run of just 1,000 pairs





BOE ALTA

-

The fruit of a multinational collaboration between a German design team (Lunar) and a Chinese semiconductor specialist (BOE), the Alta is a 55-inch edgeless glass and anodised aluminium 4K TV that automatically adjusts its picture to match the ambient light conditions. The integrated sound bar features a 50 per cent perforation pattern to ensure the best possible audio dispersion, and has also been engineered to double as the set's stand. ¥19,800 boe.com





Made in England, Bremont's second marine chronometer includes some idiosyncratic features such as three separate time zones, a 30-day power reserve, date complication and 90-day chronograph. The skeletonised

design sits in a water-resistant aluminium housing, with the chronometer's twin fusée movement goldplated, to further protect it from salt-fog damage. Launched to honour Bremont's involvement as timing partner to the America's Cup, this is a special edition of just ten. £55,000 bremont.com



COPLAND DA 215

Olé Möller's
Danish audiophile
brand has been
specialising in
valve-based
hardware since
the mid 80s. The
DA 215's resolutely
functional
aesthetic holds

an array of highend components and can handle both digital and analogue sources – ensuring that everything from a MacBook to a turntable can be plugged in. The unit itself serves as a combination DAC, pre-amp and headphone amp, so you can easily hook up headphones or listen out loud. £1,798 absolute sounds.com



The B2 is 125mm deep and 284mm in diameter, and weighs 14.15 kilos







FOCAL SOPRA NO. 2

At almost half the size of the brand's flagship **Grande Utopia** EM floorstander, the 55kg Sopra No. 2 is a no-holdsbarred highfidelity speaker for the space conscious. The wedge-shaped enclosure allows the sound waves from the rear of the tweeter to be effectively absorbed, reducing distortion by 30 per cent in the process. The beryllium tweeter itself is sandwiched between twin 180mm woofers and a 165mm midrange. £9,599 focal.com



HASSELBLAD H5D-50C WITH WI-FI

The upgraded H5D-50c featuring Wi-Fi capability for the first time is built around a 50MP CMOS image sensor measuring a gargantuan 32.9mm x 43.8mm. Shutter speeds range from 1/800th of a second to 34 minutes, with an improved capture rate of 50 images per minute. Combined with its powerful sensor, the high ISO rating of 6,400 helps maintain image accuracy even in very low light conditions. £20,394 (inc 800mm lens) hasselblad.com





oppo

PM-3

Closed-back Planar Magnetic Headphones

Now available in red and blue





Don't even bother reading this review - just go out and buy these headphones



...this is a superbly built, exceptionally comfortable and immensely talented headphone



66 10/10 33

The OPPO PM-3 are some of the best portable headphones ever made

SOUND

Simply put, the OPPO PM-3 are my favourite closed-backed headphones currently available

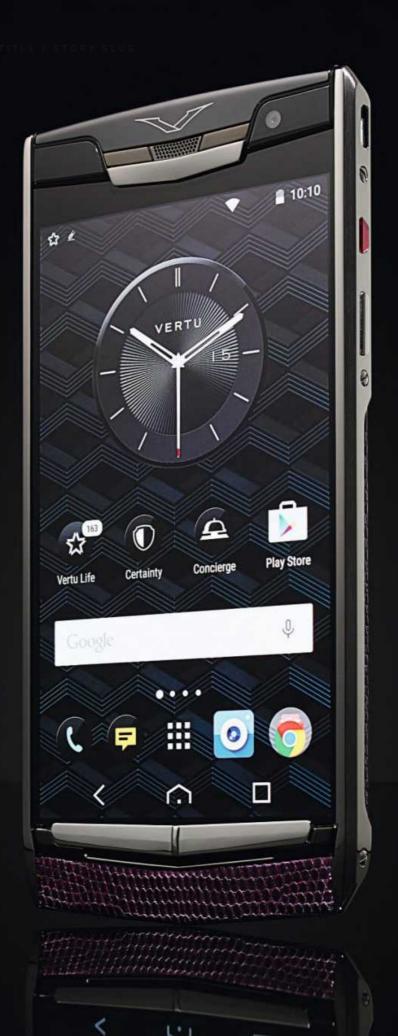


oppodigital.co.uk

VERTU NEW SIGNATURE TOUCH

This secondgeneration Signature Touch demonstrates that Vertu cares as much for class-leading functionality as precious metals and a concierge service. With a Qualcomm Snapdragon 810 chip and 4GB of RAM to call upon - double that of the iPhone 6s – the New Signature Touch is a serious smartphone. Its 130-carat scratch-proof sapphire screen has also grown to 5.2 inches, and the rear camera now has a 21MP, F2.2 sensor. £poa vertu.com

No.

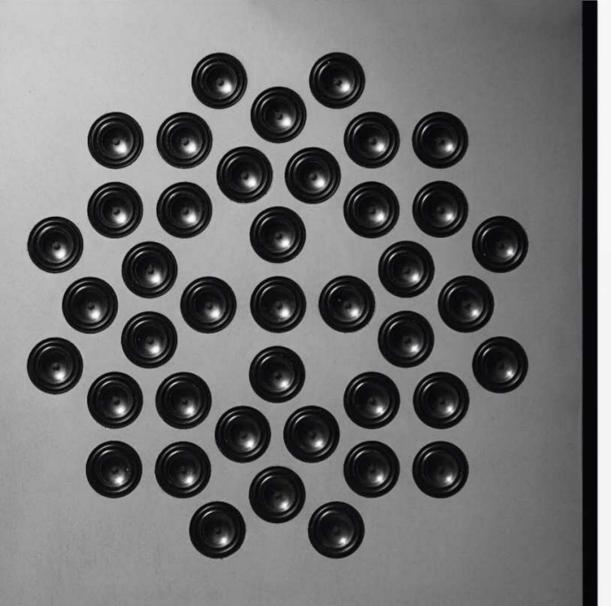




No.

The FI weighs 12kg and is 575mm tall, 390mm wide, and 32mm deep





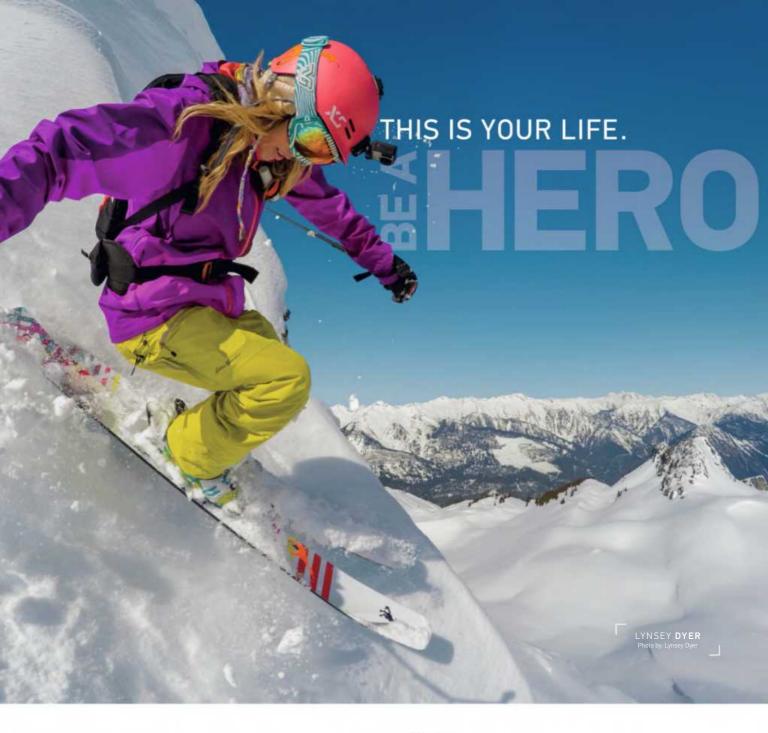
CONCRETE AUDIO F1

Germany's Concrete Audio has applied the material's rigid, free-form characteristics to create a floor-standing loudspeaker (the N1), and this flat, wallmountable design - the F1 - that is actively powered and wireless enabled. The distinctive flower pattern used for the speaker is a patented array technique comprising 41 electrodynamic drivers that behave like one continuous membrane. €7,200 concreteaudio.com



Tablet extra!

Download the WIRED app to read further specs for these items





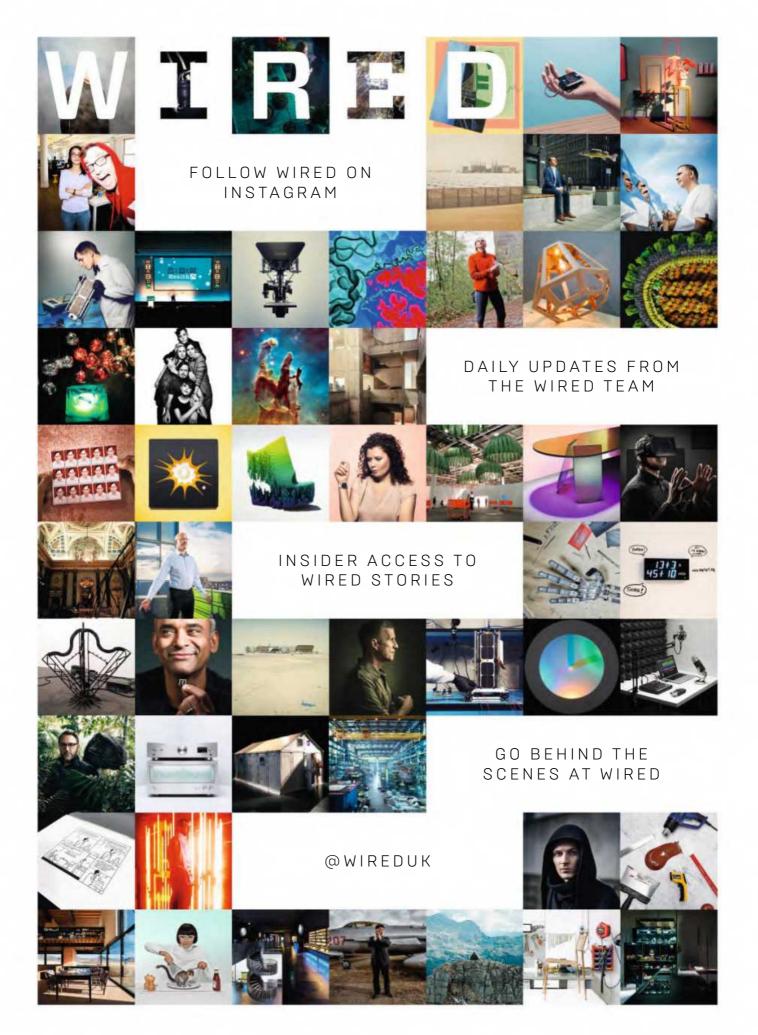












WIRED took over the dedicated listening room at London-based hi-fi specialist **Audio Lounge** (audiolounge. co.uk) and enlisted professional sound engineer Jonny Firth from vinyl mastering studio Gearbox Records (gearboxrecords. com). Firth chose a range of music to listen to - from Gearbox's own

vinyl pressings to a Spotify stream – to establish which headphones provide the most bang for their considerable bucks. He played the tracks through a Clearaudio Ovation turntable (£5,995), a Devialet Expert amp (£poa), an Audio-Technica HA5050h headphone amp (£5,000), a Nagra CDC (£8,500) CD player and an iPhone 6.



WIRED puts five money-no-object headphones to the test - but which hit all the right notes?

DYNAMIC VS PLANAR MAGNETIC HEADPHONES

Dynamic headphone drivers are essentially mini speakers: an ultra-thin wire creates a magnetic field which rapidly moves the voice coil and speaker diaphragm. That, in turn, compresses and decompresses air to create sound. With planar magnetic

headphones –
of which Oppo
and Audeze
are leading
proponents –
the single coil
is replaced by
a large surface
membrane with
magnets on either
side, causing the
entire diaphragm
to push or pull
when a music
signal is applied.

GRADO PS1000e

Wearing the Grados, the grin on Jonny Firth's face spoke volumes. "The sense of space is incredible," he says. "I can hear the reverb from individual instruments." Handmade in Brooklyn, these were the heaviest 'phones on test. They leak the most noise and come in a cheap cardboard box, but they "help you feel the air in the recordings". However, Firth did note that he preferred the calmer sections, "otherwise there's almost too much going on in your ears". They suffered slightly on rock tracks, missing the urgency of some of his selections, but more often than not they gave a perfect recreation of the song. 8/10 £1,699 gradolabs.com

OFESSIO,

PS1000e

SPEC

Cable length 3m Drivers 50mm dynamic Frequency response 5Hz-50kHz Weight 650g

TEST 2



AUDIO-TECHNICA ATH-W1000Z

"I thought the highly polished teak finish was plastic, which put me off," says Firth of the ATH-WI000Zs.
"But the floating mount makes them light and comfortable, with minimal sound leakage." Listening to jazz, they "lacked space, warmth and bottom, and were boring compared to the Grado," but performed much better with rock and pop, despite feeling compressed. They were comparable to the more expensive Audeze for audio quality, with a casual sound suited to everyday listening and, at the price, better value. 7/10 £599 audio-technica.com

SPEC

Cable length 3m Drivers 53mm closed back OFC (oxygen free copper) coil dynamic driver Frequency response 5Hz-42kHz Weight 320g



AUDEZE LCD-3

Powerful and engaging, the LCD-3s performed admirably across all music formats. Firth notes a "live and accurate sound with a spacious feel" listening to jazz, and that they "sound much more enjoyable than the rest for pop." He did feel something was

missing at the extreme ends of the frequencies, however. It's the comfiest on test but the premium build – including gorgeous Zebrano wood and plush leather – is let down by a poorquality cable.

A pity, given the price. 7/10 £1,599 audeze.com

SPEC

Cable length
2.5m
Drivers Planar
magnetic
Frequency
response
5Hz-20kHz
(extended out to
50kHz)
Weight 548g



OBRAVO HAMT-1

Despite the lavish looks and premium materials, Firth wasn't impressed: "Compared to the Grado, they lack sparkle and they overly focus on the low- and midend." Build quality was also an issue, with several screws coming loose. The cable is poor for such

an expensive pair of headphones: "Are they really just meant for listening to your MP3 player?" he asks. Rock tracks fared worst of all: "They're missing detail, the bass is unnecessary and they lack control." 3/10 £1,499 absolute sounds.com

SPEC

Cable length Im Drivers 40mm Air Motion Transformer tweeter in acoustic centre of 57mm cone mid/bass Frequency response 15Hz-45kHz Weight 540g



OPPO PM-1

Presented in a hardwood display box, the PM-1s are extraordinarily well made, with an unmatched, executive feel combined with all-day comfort. Listening to jazz on vinyl, Firth commented on "the sax really seeming to be out in front where it should be, but

overall it left me feeling like I was standing right in front of the musicians, not enveloped in the room." Although lacking "a bit of zing", they offer a solid, enjoyable listen across genres – even on the iPhone.
6/10 £1,099
oppodigital.com

SPEC

Cable length 3m Drivers 85 x 69mm planar magnetic Frequency response 10Hz-50kHz Weight 395g (excluding cable)



STEINWAY HALL LONDON 44 MARYLEBONE LANE, LONDON W1U 2DB

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A PERFECT MATCH

A startup is challenging niche perfumery with an approach that blends customisation and convenience >

Words by **Henry Farrar-Hockley** Photography: **Jake Curtis**



ne of the great challenges facing today's luxury goods industry is how it engages a consumer culture that's big on instant gratification - without compromising on quality. True "bespoke" remains the apogee of all things high-end, yet it takes time to execute it successfully - be it a notch-lapel Gieves & Hawkes suit in Super 150s Dormeuil wool, or a pair of patinated Venezia leather Oxfords by Berluti. Nowhere is this as apparent than the realm of fine fragrance, where the roster of reputable bespoke perfumers is a short one (Lyn Harris, Azzi Glasser and Roja Dove are the three to know), and tailoring a scent can take years to realise.

Bridging the gap between massmarket ubiquity and the unique formulations of made-to-order are the so-called "niche" perfumeries. These utilise rare and expensive ingredients to sell rare and expensive fragrances, occasionally with some small degree of personalisation on the flacon. This has fast become a saturated sector, the high price tags sadly guaranteeing neither quality nor exclusivity. However, a scent brand from Paris, Ex Nihilo (Latin for "out of nothing"), is challenging the olfactory status quo. Its demi-bespoke concept provides the best of both worlds: customisable perfumes that take less than an hour to distil, thanks to a combination of technological innovation and old-fashioned artisanal skill.

The brand's founders comprise a French advertising guru (Benoît Verdier), a Swedish banker (Olivier Royère) and a French-American perfumer (Sylvie Loday), who between them have curated a collection of nine original scents. A row of identical glass "Vases de Senteurs" sits the front of each boutique (there are outposts in Paris, Moscow and London – the latter at the Harrods Salon de Parfums – with the US to follow in 2016). These digital atomisers release a concentrated dose



of each fragrance from an alcohol-free dry capsule – ensuring it causes neither environmental pollution nor lingering odour. Each *Vase* is also unlabelled, so that the customer judges the scents without fostering any preconceptions based on preferred ingredients or name. WIRED's new-found favourite? Vetiver Moloko, a formula inspired by the eponymous bar in *A Clockwork Orange*, and containing an addictive infusion of vetiver wood, vanilla and – rather unusually – a milk note.

The bespoke element comes into play once a core fragrance has been chosen. A supplementary ingredient of the customer's choosing can then be added to the mix – albeit from a selection of notes that have been carefully validated

Above: One of Ex Nihilo's nine scents is blended with an additional ingredient in the Osmologue

by the original perfumer to ensure compatibility. This new "juice" is sent via a custom Windows tablet to the Osmologue - a high-precision robotic dosing machine that combines the exact concentrations of alcohol, water and raw materials required - before the solution is blended for precisely 30 seconds on a magnetic plate. The bottle's spray mechanism is finally secured in place using a traditional lever clamp. The inlay of the bottle cap can also be customised with a variety of materials, ranging from the expected (mother of pearl, buffalo horn) to the unorthodox, such as pulped and compressed copies of Le Figaro that create intricately striated patterns. Personalised 100ml eau de parfum from £240 ex-nihilo-paris.com

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DESPITE THE WATCH INDUSTRY'S DESIRE TO ELUDE TRENDS, each year it seems to achieve the opposite: from skeletonisation to perpetual calendars, fine timepieces are split into categories so they can be easily processed and, their makers hope, invested in. The theme among the designs here is a spirit of innovation – an ever-present force in horology since John Harrison first set his mind to solving a problem called longitude.



WATCHES

Audemars Piguet Royal Oak Concept Laptimer Michael Schumacher

1

IN WATCHMAKING, the mention of a "concept" generally refers to something so resolutely forward-thinking it's unlikely to make it on to the wrists of consumers. It's a construct that allows watch designers to experiment without conventional constraints – although this can't be said of Audemars Piguet. Take its Royal Oak Concept Laptimer Michael Schumacher: in 2010, the seven-times Formula One champion (and brand ambassador) asked if a motorsports-centric mechanical watch could be realised that would measure and record an extended series of consecutive lap times. Five years later, the manufacturer has achieved a first: a single chronograph driving two central hands controlled independently via three pushers. The upshot? You can now record the time of your most recent lap around Interlagos while the timing of your next lap is already underway. The Concept Laptimer is a limited edition of 221 – representing the number of Schumacher's points-winning races during his F1 career. £175,200 audemarspiguet.com



IWC Portugieser Sidérale Scafusia



THE SCAFUSIA features an astrolabe on its back that's calibrated to the owner's specifications (there are more than 200 ways to customise this watch, from case materials to dial finishes). This ancient astronomical computer was designed to solve problems relating to time and the position of the Sun and stars in the sky. Taking ten years to realise, the piece was developed under the watchful gazes of Ben Moore (professor of astrophysics at the University of Zurich), Jean-François Mojon (the brains behind the movement for Harry Winston's Opus X) and IWC's head of R&D, Thomas Gäumann. It also features a patented constant-force tourbillon, a power reserve, "sidéreal" time and a perpetual calendar. All of this is made possible by IWC's bespoke 94900 calibre – a hand-wound movement powered by two barrels, which provide two days' constant power to the tourbillon. It's not limited edition *per se*, but the amount of work that goes into its manufacture means that only a few Scafusias are produced each year. £poa iwc.com



Omega Seamaster Ploprof 1200m



THE NAME "PLOPROF" is a portmanteau of *plongeur professionnel* – "professional diver" in French – and was bestowed upon a 1970 Omega model specifically designed to endure the bone-crushing pressures that deep-sea divers experience while underwater. The design underwent a reboot back in 2012 and now, in 2015, it has received its second update. This reissue is not only water resistant to an astonishing 1,200m but has also been fitted with the Calibre 8900, which contains both Omega's non-ferrous anti-magnetic technology and its Co-Axial Escapement, making it reassuringly accurate, even at extreme depths. There is also the protected crown, an automatic helium escape valve and, of course, the distinctive bright orange security pusher on the right-hand side that, when depressed, allows the bi-directional rotating bezel to be manipulated. £6,150 omegawatches.com



Bell & Ross BR-X1 Carbon Forgé



LOOKING AKIN to something recovered from the wreckage of the Death Star, the BR-XI bills itself as the "ultimate utility watch". Its case is made from forged carbon, a lightweight, ultra-resistant material, which, rather than being layered for the distinctive, checked pattern of carbon fibre, bonds string-like pieces of the material with thermosetting resin. Exposing them to intense heat and pressure leads to the signature "marbling" effect. The watch also uses ceramic for its corners, lugs and rocking pushers, as well as titanium and rubber. Under the grey-tinted anti-reflective sapphire glass lies the BR-XI's true centrepiece: a skeletonised movement that's an amalgam of a Dubois Dépraz chronograph and date module on an ETA base, with Super-LumiNova-filled hour and minute hands and an aluminium 30-minute timer disc. £14,900 bellross.com



Graff GraffStar Slim 43mm Black DLC



THINK OF GRAFF and you will doubtless picture diamonds – flawless, highly-polished ones at that. However, the British multinational jeweller has, since 2008, also been quietly investing in its watch development. True to form, the timepieces are occasionally stone-set, but they are also exceptionally well constructed. The division is based in Geneva and the collection includes Graff's own calibres – and even a flying tourbillon. This stealth-black design has all the Graff watch signatures: the faceted case is inspired by a perfectly cut diamond, yet somewhat unusually it is also encased in an ultra-light titanium that has been DLC-coated. Thanks to the inclusion of the brand's Calibre 3 self-winding movement, it is only 6.35mm thick, hence the "Slim" moniker – despite its 43mm case. There are no big, splashy diamonds in sight, although Graff does offer a bespoke inlaying service for those who prefer a little ice on their wrist. £poa graffdiamonds.com



Patek Philippe 5370P



AN ORDINARY LAUNCH by Patek Philippe would be enough to get watch connoisseurs number-crunching, but this split-seconds chronograph is no ordinary Patek. First of all, a complication with an explanation: a split-seconds chronograph, or rattrapante, is used to time different events that begin together but do not end simultaneously. The two buttons on the crown allow the two hands to be operated independently of each other, although they can conveniently be stopped and returned to zero together. Patek happens to be the progenitor of split-seconds watches, completing its first such design in 1923 – an example of which sold last year at Sotheby's New York for \$3 million [£2m]. Since its inception, this singular complication has been a major part of the brand's storied canon, but this is the first pure, two-button version Patek has made since the 70s. Then there's the movement, which is based on the ground breaking, manually wound CH 29-535 PS. £164,060 patek.com

HOW WE TESTED

Both systems were auditioned using a 5.1.4 speaker configuration, with WIRED sat in the optimal position. In addition to a **Dolby Atmos test** disc comprising assorted Atmos sequences and trailers. WIRED played specific scenes from the Bluray discs of The Hunger Games: Mockingjay Part 1 and Transformers: Age of Extinction, both of which feature dedicated **Dolby Atmos** soundtracks.

The systems

with non-

were also tested

Atmos surround

two-channel CDs.

Everything was

played very loud.

software and



DENON AVR-X7200WA/ DEFINITIVE TECHNOLOGY BP8060ST SYSTEM

A brawny nine-channel affair, Denon's integrated network receiver is rated at a toupee-lifting 150W (into 8 ohms), but can handle up to 11 channels with the aid of additional stereo amplification. Opt for either a 5.1.4 Dolby Atmos layout (two rear and four height speakers) or 7.1.2 (four rear and two height). This box is also firmware upgradable to DTS:X – Dolby Atmos' main competitor. Connectivity is superb: there are eight HDMI inputs supporting HDCP 2.2 copy protection, ensuring compatibility with your next 4K Blu-ray, BT or Sky box. There's also Wi-Fi and Bluetooth for streaming music from networked and mobile devices. We used speakers from US hi-fi specialist Definitive Technology. The bipolar BP8060 SuperTower floorstanders each have a 300W subwoofer built-in, while the up-firing A60 height speakers neatly lock on to the top of each cabinet. In full flight this blockbuster pairing sounded positively apocalyptic. The Hunger Games became thrillingly immersive, with seismic bass and blissfully sweet highs. And you aren't restricted to native Atmos content with this setup, as it also offers faux height using conventional two-channel soundtracks. **9/10** £2,499 denon.co.uk; £4,625 definitivetech.com

SPEC

Channels of amplification Nine HDMI ports Eight in/three out (all HDCP 2.2 compatible) Weight 17.1kg Features DTS:X upgradable, 4K 60Hz video up-scaling, auto eco mode

LISTEN UP

Can 3D audio really deliver the next dimension of home cinema? WIRED turns up the dial on two flagship Dolby Atmos AV systems

< ONKYO TX-NR3030/KEF R SERIES

Unlike the Denon, Onkyo's offering features a competition-crushing II channels of amplification as standard, and you can deploy a full 7.1.4 Atmos setup straight from the box. Connectivity includes seven rear-facing HDMI inputs and a single front-facing port. However, just one of these is HDCP 2.2 ready, and there's no option to firmware-update the receiver for DTS:X. Wi-Fi and Bluetooth are integrated, and the build quality is decent. The Onkyo receiver's speaker support comes from KEF. With its trademark wide-dispersion Uni-Q drivers and piano gloss finish, the R Series package looks attractive and professional, with the up-firing R50 Atmos-enabled speakers a cosmetic match for both the stereo R500 floorstanders and compact R100 rears. Audio performance is outstanding: the receiver offers precision when it comes to image placement, and is a lighter, tighter listen than the Denon. The quoted power output figures are a vague 185W into 6 ohms, with one channel-driven, but there's little doubting the tremendous power on tap. If you have the room to accommodate it, the thrills are considerable. **8/10** £2,499 onkyo.com; £4,950 kef.com

SPEC

Channels of amplification 11
HDMI ports Eight in/three out (one HDCP 2.2 compatible)
Weight 22kg
Features THX
Select2 Plus; seven 32-bit
Burr-Brown D/A converters; 2160p video up-scaling

DOLBY ATMOS -HOW IT WORKS

Whereas 5.1 and 7.1 systems generate sound on a horizontal plane, Dolby Atmos uses two or four "height" speakers (5.1.2 or 5.1.4). Installing height channels isn't always easy, so Dolby Atmos-enabled speakers have up-firing drivers which bounce the additional audio channel off the ceiling to achieve the desired effect.

NEVER MIND THE

current stellar crop of super-high-end home hi-fi systems – what options are there for the itinerant audiophile? This year has brought a relative boom for personal hardware marketed at hi-fi connoisseurs, from high-res audio devices such as the Kickstarter-funded PonoPlayer, to OPPO's svelte HA-2 combination DAC/ headphone amp. Yet this new-found convenience is not entirely, well, sound: cabling together the pocket players with thirdparty amps tends to turn these mobile systems into cumbersome, tangled bricks.

The best reference-grade headphones, meanwhile, are still better suited to the living room than the London Underground, no matter what their makers say.

Enter Astell & Kern, the iriver offshoot that has been making a play for the personal hi-fi space since its inception in 2012. The South Korean marque's new, £3,000 AK380 player (right) houses dual 32-bit DACs under its duraluminium shell, is fluent in every conceivable

lossless audio format and has 256GB of expandable on-board storage, alongside Wi-Fi streaming capability. There's also an optional AK380 amp (£499) engineered to drive highimpedance headphones, it screws seamlessly on to the player with no need for additional wiring (and it doubles the battery capacity). Completing the package is Astell & Kern's ace in the hole, the pleasingly slight yet resilient AK Ti8e earphones (£799), capable of reproducing the entire frequency range. The world's first in-ear-style headphones to accommodate Beyerdynamic's Tesla technology, their unique, low-distortion single-driver design uses a powerful ring magnet with no need for crossover filters. They also feature a 2.5mm four-pin plug to fit the AK380's balanced output port. astellnkern.com

 $ASTELL \& \, KERN \, AK380 \, PLAYER$

ASTELL & KERN AK TISE EARPHONES

The AK380 uses a capacitive-touch metal interface for its home button







